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AND

ALLIED SCIENCE

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Head, Wounds of the.—In beginning the consideration of the injuries to the head, there are certain anatomical and physiological conditions which are worth recalling to mind on account of their immediate bearing on the effects of the injuries, and in their treatment. We leave to the domain of the other special regions the consideration of the wounds of the eye, ear, nose, and oral cavity, and also the brain, except as they are intimately associated with injuries of the head in general.

Anatomy and Physiology.—In the *superficial soft tissues* of the other parts we note first the extensive attachment of the skin of the scalp by numerous fibrous bands to the musculo-aponeurotic layer of the occipitofrontalis muscle so that when traction is made on the skin over a large area, as when the mass of a woman's long hair is caught in a wheel belt, the skin, fat, and occipitofrontalis muscle are pulled off at one time, scalping the person down to the pericranium. For the same reason deep hemorrhage and deep suppuration tend to spread over a larger area than the superficial abscess or hemorrhage. The deep fluid undermines the entire scalp because of the slight adhesions, while the superficial condition is much more limited on account of the attachment between the skin and the muscle aponeurosis.

The pericranium is adherent to the bones at the lines of suture so that subpericranial hemorrhage is limited by the outline of one bone. The pericranium also is very poor in its ability to produce new bone, so that after fracture or bone defect, there is very little new callus formed and very little new bone, and the bony defect is liable to be permanent.

The *blood supply* to the scalp is by the occipital, temporal, and supraorbital arteries on each side, all of which run from the periphery of the vault of the skull toward the vertex near which they anastomose freely. Hence it is wise always to make any operative skin flap with its attachment toward the base of the skull and so located, if possible, as to center around one of these arteries. Hence also the free bleeding from scalp wounds may be controlled surely by a tourniquet that surrounds the head and compresses all of these vessels against the skull, while ligation of one of the external carotid vessels may fail to control the bleeding. The free anastomosis between the extracranial and intracranial veins is also of great importance in partially compensating for increase of intracranial pressure, and equally important in a less comforting way by making possible or probable the spread of infection from the extracranial regions to the interior of the cranium, as is seen in the extension of the thrombus from the mastoid vessels into the cavernous sinus and then down into the internal jugular vein. Hence also we look for meningitis and brain abscess as sequelæ of the extracranial infections especially facial erysipelas.

The *lymphatic vessels* inside the cranium follow the main blood-vessels and terminate in the upper deep cervical glands. Some of the meningeal vessels empty into the zygomatic lymph nodes on the buccinator muscle and anterior part of the wall of the pharynx. The superficial lymph vessels from the anterior parts of the scalp join the temporal vessels to the parotid nodes or the facial vessels to the buccal nodes. From the temporoparietal regions they go to the preauricular parotid nodes or to the post auricular mastoid nodes. From the occipital parts of the scalp the lymph vessels lead to the occipital nodes over the upper part of the trapezius muscle.

In the *bones* of the skull we note primarily that we have a rigid slightly elastic brain box so that if for any reason we get increased pressure inside the cranium

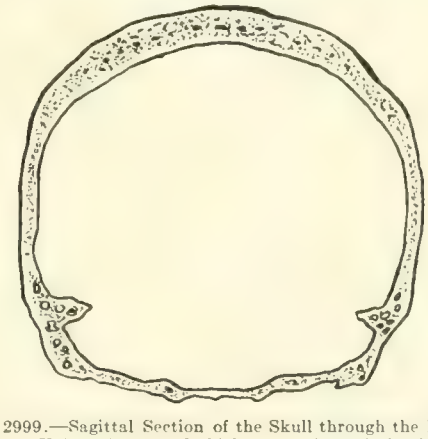

Fig. 2999.—Sagittal Section of the Skull through the Foramen Magnum. Uniformly curved thick vertex, irregularly thickened, almost flat base; diploe with external and internal plates in the vertex.

there will be an attempt to press the cranial contents out at the large foramina notably at the foramen magnum and the optic foramina. A section of the skull either sagittal or coronal shows the evenly curved more or less uniformly thick bones of the vertex as compared with the almost flat base where there are great irregularities in thickness. In the base there are some very thin portions, many foramina and some very thick regions. There are certain thick-edged foramina, for example the foramen magnum where the thick edge fortunately tends to protect the foramen against fracture and there are other foramina with thin edges for example the foramen ovale and the posterior lacerated foramen which are frequently involved in the course of the line of fracture. The thin portions of the base which lend themselves to directing the line of fracture can easily be seen by holding a dried skull to the light. In the anterior fossa we note the thin parts of the orbital plates of the frontal bone toward the median line, and the cribriform plates of the ethmoid

bones. In the middle fossa we note the greater wings of the sphenoid and the glenoid fossa and squamous portion of the temporal bone. In the posterior fossa we remark the very thin floor of the cerebellar fossa in the occipital bone, the jugular fossa and the tympanic cavity in the petrous portion of the temporal bone. In cutting through the bones we note the two layers of dense bone on the outside separated by a layer of cancellous tissue which makes possible the fracture of either table of dense bone without any change in form of the other table. In certain regions of the skull this cancellous structure is developed into large air cells from which we may get air into the tissues after a fracture of the overlying dense bone, accounting thus for the emphysema of the subcutaneous tissues occasionally seen after fracture of the mastoid or frontal bone.

Of the *intracranial soft parts* we note the adherence of the dura to the bones at the sutures and along the venous sinuses which is important in limiting the extent of the extradural hemorrhages as distinguished from the subdural hemorrhages which have no such fascial limitation. The mesh-like structure of the arachnoid tends to hold lightly in one region the blood or serous fluid that may accumulate beneath the dura after an injury and to interfere with free drainage.

The brain itself by its semifluid consistency is responsible for the hydrodynamic bursting effect of the high-speed bullet that passes through the cranial cavity. The great value of the special recognized areas of the brain as a help in localizing both bony and intracranial injuries and determining the site of operative treatment is most important. The localizing of brain injuries is fully considered in connection with the brain diseases.

The presence of the cerebral fluid which bathes the brain and communicates freely with the fluid around the spinal cord makes possible the diagnosis of pus or blood in the coverings of the brain through a diagnostic lumbar puncture when the fluid obtained will show the character of the fluid in the skull. At times too we get traumatic meningocele where the pulsations of circulatory and respiratory pressure are indicated in the swelling through the transference of the wave by the cerebrospinal fluid.

The anatomical relations of the blood-vessels inside the head are of surgical interest from the frequency with which the meningeal arteries that are embedded in part of their course in the bones are involved in injuries thus causing intracranial hemorrhage which is primarily extradural. The immediate proximity of the cavernous sinus and the carotid artery inside the skull at the back of the orbit give rise to the possibility of arteriovenous aneurysm with pulsating exophthalmos. The intimate association of the venous sinuses with the veins leads to the frequency of intracranial venous hemorrhage.

The intracranial nerves are of interest principally in diagnosis of the location of lesions. The branching of the facial nerve as it courses through the temporal bone affords opportunity to localize the fractures of that bone much more accurately than would be possible if the nerve had no branches in this part of its course.

One or two *developmental changes* are also worthy of note as modifying the effects of injuries to the head. In the child the bones of the skull are soft, bend easily and are apt to give the same type of greenstick fracture as in other parts of the body. The bones in childhood also have no diploe so that there would be no fracture of the internal table without fracture of the external table nor would there be a chance of subcutaneous emphysema. The dura at this stage is adherent to the bone so that extradural hemorrhage would be limited. In old age the brittle skull increases the probability of fracture and the rigid arteries increase the probability of hemorrhage. The air spaces in the bones are absorbed with advancing years with the same effect as in childhood.

Wounds of the Scalp.—Wounds of the superficial soft parts of the head are very similar in all respects to those of the skin and subcutaneous tissues in the other parts of the body. On account of the vascularity of the tissues, however, there is greater evidence of bleeding. When the skin is not broken there forms a large hematoma made more evident than in other parts of the body by the hard bone just beneath The marked prominence of the hematoma is well known to every small boy. In some cases the deep hematoma gives rise to the suspicion of fracture of the skull because the center of the hematoma softens, while the hard edges assume almost a bony hardness suggesting on palpation a depressed fracture of the skull, but in these hematomata the hard edge of the clot is not bony hard, and it is raised above the level of the rest of the bone. The center of the area is smooth with no angular deformity. Such hematomata usually clear up in a few days with the application of some cooling lotion such as aluminum acetate. At times they may need to be aspirated or if the clot is very slow in absorption the swelling may need to be incised and sutured. When infected they need incision and drainage.

If the skin is broken by the contusion the straight line of the broken skin may suggest that the injury was inflicted by some cutting instrument when it really has been inflicted by some blunt instrument, a point noteworthy in certain medicolegal cases. It is of interest that the wounds of the scalp do not gape wide open as wounds elsewhere tend to do, and yet the wounds bleed very freely on account of the generous blood supply. The facts that the wounds do not stand open, and that they are frequently through a hairy, more or less dirty, scalp increase the probability of infection which is counteracted in part by the free bleeding. In such scalp wounds surgical cleanliness is of the utmost importance in preventing infection of deeper tissues; cutting off the hair or shaving the scalp if there is much laceration, cutting away any ragged tissue, disinfecting the region best with a solution of iodine three per cent. in alcohol (a mixture of equal parts of alcohol and tincture of iodine may be more convenient to make and is practically the same, but the additional potassium iodide adds to the expense and not to the value), and closing the wound if possible by suture, preferably catgut. A dry sterile dressing is applied if any at all is necessary. Many small scalp wounds may be left with no protective dressing.

Avulsion of the entire scalp is not an uncommon injury when the coils of a woman's hair are caught as a whole and suddenly and forcibly wrenched as when the hair is entangled in machinery belting. In such instances the tissues down to and including the occipitofrontalis musculoaponeurosis are torn away. In such cases if there is any pedicle holding the loosened scalp to the other skin and subcutaneous tissues, it should be carefully saved as even the smallest pedicle may carry one of the vessels, which thanks to the free anastomosis possibly will give life to the entire scalp. Even if there is no pedicle and the scalp is fresh and clean it may be worth while attempting to use the entirely free scalp as a skin graft. Suture it in place and apply a dressing bandage which will hold the scalp in close apposition to the pericranium. Careful watching of the scalp will enable one to remove any necrotic portions before they do the patient any harm and to retain any living portions to cover the almost denuded bone. If the scalp graft is not available or fails to grow, recourse must be had to skin grafting to shorten the tedious period required for the wound to epitheliate over from the edges of the wound. In all the dressing great care must be taken to avoid the application of the strong antiseptics which at the same time that they inhibit the growth of the infectious agents also inhibit the growth of the normal tissue cells. Phenol

and bichloride of mercury are to be carefully avoided; and potassium permanganate, one per cent. solution; or boric acid, saturated solution, preferred. In all wounds of the head, and face especially, the cosmetic results are kept in mind and the best possible scar obtained. With this in mind also we must try to obtain union of the muscles that are so important in the expression of the face, and also of the nerves that supply those muscles.

In the injuries to the head infection must always be guarded against as far as possible on account of the chance of the spread of the infection through the blood-vessels into the interior of the brain leading to the intracranial infections, meningitis, brain abscess, and phlebitis. Disinfection with iodine should be thoroughly carried out.

Injuries to the Bones.—The injuries to the bones of the skull are practically limited to fractures. These are important not on account of the injury to the bone itself or to the muscle attachments, as in the long bones, but to the cranial contents. Fractures of the skull, like fractures in other parts of the body, may be simple or compound and as such differ in their treatment and in their symptoms. In one respect the simple fracture may be much more dangerous to life than the compound for in the compound there is often an avenue of escape for intracranial contents which is not present in the simple fracture, and by the escape of this intracranial contents whether cerebrospinal fluid, blood, or even brain tissue the greatest danger of excessive intracranial pressure may be avoided. The compound fracture, however, opens the chance for intracranial infection which is always a very serious complication. The possibility of a compound fracture of the base of the skull where the opening in the bone coverings to the outside infection is in the nose, ear, mouth or some other place inaccessible to examination and to treatment makes the question of compound fracture always one needing careful consideration.

In fracture of the bones of the face as perfect alignment as possible should be obtained and in cases of marked deformity suture with chromicized catgut should be considered.

The *classification* of fractures of the skull into those of the vertex and those of the base is a very convenient grouping because of the difference in the type of fracture most commonly found in the two situations, and in the causation of the fracture in the two regions. Though the types are not limited to the two localities, the more common type of fracture in the vertex of the skull is due to direct violence applied over a comparatively small area, bending the bone sharply inward at one point. Such fractures follow blows on the head. On the other hand, at the base of the skull the more common type of fracture is due to bursting of the skull from compression between two large surfaces or against a single large surface when the skull as a whole is flattened. The mechanism of these bursting fractures is readily appreciated if we watch the cracking, not complete crushing, of an English walnut in a pair of nut crackers. We note the opening of the crack in the meridian connecting the two poles at which pressure is applied. The fissure will open widest on the equator midway between the poles and least at the poles. Similarly in the skull the result of general compression is a fissure extending from pole to pole and going through the weakest and least elastic meridian connecting the two poles at which pressure is applied. Such fractures occur when the head is run over by a wagon wheel or caught between two boxes, or in the more common single pole compression that follows when one slips and falls striking the head on the ground. Here we anticipate the fissured fracture extending from the point of contact through the base because the base is less elastic than the vertex. An entirely different type of bursting fracture of the skull is seen in the perforating gunshot wounds where the brain box, filled with semifluid brains, is burst like the barrel filled with water when perforated by a bullet. Instead of the clean-cut perforations at the point of entrance and exit of the empty barrel there is a comminution of the brain box, or barrel, from the sudden increase in pressure in all directions from the inside giving fissures in both meridians of longitude between the poles, and in circles of latitude around the poles of entrance and exit of the bullet. The fissures follow to a certain extent again the lines of least elasticity.

In other less common cases we may find the uniformly elastic vertex of the skull involved in the fissured bursting fractures from compression; while the base of the skull is accessible also to the bending fracture of direct violence, applied for instance through the lower jaw bone to the glenoid fossa by a blow on the point of the chin, to the occipital bone by a fall landing on the feet or the buttocks with the spine rigid, or what is similar by a fall landing on the vertex and having the spine driven by its own momentum against the base of the skull.

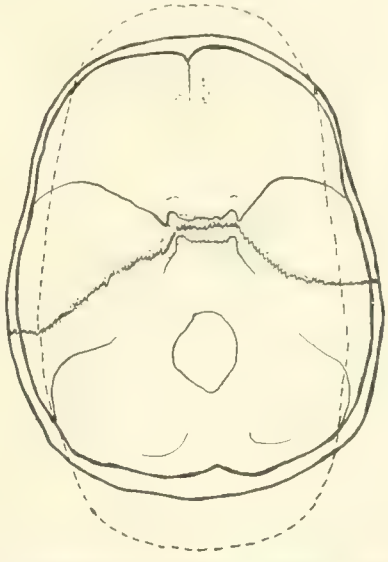

Fig. 3000.—Fracture of the Base of the Skull; head run over by wagon wheel. Broken line shows result of lateral compression on shape of skull. Lateral compression bursting skull through less elastic base. Dotted area shows widening of fissure greatest midway between poles of pressure.

The symptoms of fracture of the skull may be divided into those dependent on solution of bony continuity; blood-vessel injury; nerve injury; brain injury.

Dependent on the solution of bony continuity the loss of the normal contour of the bone may be seen in some of the compound fractures or extensive fractures that are not compound. In less extensive fractures the deviation from normal contour of the bones may be palpated. On the other hand, the normal bony contour without any change in outline is expected in all the fissures which occur in the majority of skull fractures either as part of a bending fracture or as the sole bony lesion in the bursting fractures. In determining the change in bony contour one must bear in mind the possibility of the apparent change in contour frequently seen in the deep extracranial hematoma where the elevated firm edge of the clot with a softened center has not infrequently been the indication for an operation on a supposed depressed fracture. On palpation of the skull we can rarely get bony crepitus except in the comminuted fractures. In some cases there may be found emphysematous crepitus after subcutaneous fracture of the bones with

large air cells like the mastoid and frontal bones. The local tenderness, however, is determinable in practically all of the conscious cases and is of inestimable value in the linear fissures where it may be the sole diagnostic sign. If one goes over the field of injury and finds a sharply defined line of extreme tenderness on pressure made with a small hard pointer such as the blunt end of a lead-pencil, unless that tenderness can be accounted for by the course of a nerve or some other equally potent cause for sensitiveness, the diagnosis of fracture can be considered as reasonably established. Naturally one looks for such lines of tenderness in the most common lines of fracture that are accessible to palpation, such as the temporal fossa and the mastoid region, and we anticipate that the line will run from the base toward the vertex. On percussion of the skull we may get a cracked pot sound. An *x*-ray examination should be made in every doubtful or suspicious case. Good *x*-ray plates appreciatively interpreted will throw a great deal of light on the question of fracture in the unconscious patient where few other signs of fracture can be elicited. And not only does the Röntgen examination make the diagnosis, but it locates the fracture and determines the site of operation, if such should be necessary, more quickly and with less disturbance to the patient than most other forms of examination. Such an examination should include plates taken of frontal, occipital, and each lateral region of the skull.

Dependent on vessel injury we have to consider the hemorrhage external to the skull and that internal to the skull. External to the skull we may have hemorrhage from an open wound in the scalp. This will be directly at the site of injury. But in fracture of the base the hemorrhage may travel over one of several mucous membrane channels before it becomes evident. It may come from the external auditory canal in fracture of the temporal bone with laceration of the drum membrane. The bleeding may come from the nose after fracture of the cribriform plate of the ethmoid or from nose and mouth after fracture of the body of the sphenoid directly through the pharyngeal mucosa; or from nose and mouth after fracture of the temporal bone without laceration of the drum membrane so that the blood flows down the Eustachian tube into the nasopharynx. Again the blood may be vomited after being swallowed.

If there is no break in the superficial soft parts so that the blood can escape, it follows the lines of least resistance and appears under the skin either immediately over the fracture, or directed by the fascial planes, the ecchymoses appear at a distance from the fracture. In the occipital region the distant ecchymosis appears in the muscles of the neck; after fracture of the temporal bone one looks for the ecchymosis over the mastoid or along the sternomastoid muscle, in the frontal region one expects the distant ecchymoses in the orbit, eyelids, and malar region or one sees subconjunctival hemorrhage. In fractures of the base one may find a submucous hematoma in the roof of the pharynx. When the carotid artery is injured as it passes through the cavernous sinus there may develop an arteriovenous aneurysm which communicates the arterial pulsation to the protruded eyeball, a pulsating exophthalmos.

From injuries to the nerves we get symptoms of irritation or more commonly of paralysis of the nerve that is injured. The injury most frequently occurs at the point of exit of the nerve from the skull and so is almost limited to fractures of the base. Any of the cranial nerves are liable to injury. The one most commonly affected is the seventh giving paralysis of the muscles of the face. In most of these cases we have a fracture of the temporal bone usually through the stylomastoid foramen. Perhaps it is on account of the ease with which this paralysis of the seventh nerve is determined that it is the most frequently found. It takes a more careful examination to elicit the paralysis of some of the other cranial nerves. Associated with the paralysis of the seventh nerve not infrequently we find paralysis of the eighth nerve determined by the loss of hearing in one ear. Paralysis of the motor nerves of the eyes is also frequently noted. If the third, fourth, and sixth nerves are all paralyzed a not uncommon grouping, we expect to find the fracture through the sphenoidal fissure. Paralysis of the third and fifth nerves together is not infrequent, giving anesthesia of part or all of one side of the face and interference with the motion of one eye. Such paralysis occurs in fracture through the middle fossa of the base of the skull. Paralysis of the ninth, tenth, and eleventh nerves another fairly common grouping is found in fracture through the posterior fossa and gives interference with taste, swallowing, and to some extent to the motions of the head. The mobility of the pupil of the eye is dependent on the innervation and on the blood supply to the iris. These are frequently disturbed in fractures of the skull to such an extent that the condition of the pupil is well taken as one of the most significant prognostic signs. If the pupil is dilated and immobile in one eye only the cranial lesion is probably on that side. If both pupils are dilated and immobile the cranial condition is such as to make one extremely anxious as to life of the patient irrespective of what other symptoms may be present. Perhaps ten per cent. of those with dilated and immobile pupils recover.

Injury to the brain is present in practically every fracture of the skull. The slightest brain injury is concussion which in its lightest form is merely a stunning or loss of consciousness for a few moments. On the other hand, the concussion may be severe enough to cause a prolonged unconsciousness lasting many days.

Concussion is probably due to the minute hemorrhages or intracellular changes determined by microscopic examination and not by gross lesions. The symptoms are analogous to those of shock. There is unconsciousness more or less profound during which the temperature is subnormal and the pulse and respiration slowed, the blood pressure low. The muscles are relaxed and sensitiveness of the skin diminished. As the patient recovers consciousness there is headache, dizziness, nausea, vomiting, and convulsions appear in some of the cases. There is no memory of the accident. In the severest cases there is no response whatever to external stimulation, the pupils of the eyes are contracted, the conjunctival reflexes are absent. There are involuntary urination and defecation. In some cases there is excitement rather than mental depression. The concussion is to be treated like shock by quiet, external warmth, artificial pressure to the limbs and the abdomen, the head kept low and an ice cap applied to the head. Morphine and atropine should be given hypodermically. Careful watch should be kept for the development of brain pressure which is so common a sequel in cases of concussion and if the compression appears it should be treated appropriately.

There may be serious and prolonged brain symptoms due to compression of the brain by a depressed fragment of bone in which case we expect more or less localization from the symptoms dependent on the portion of the brain compressed; or there may be the more usual type of compression from posttraumatic edema or from intracranial hemorrhage. We do not find the signs of compression when there has been destruction of the bony skull sufficient to allow the escape of fluids, or brain tissue enough to compensate for the increased cranial contents caused by the injury and prevent the cerebral anemia which is the direct effect of the increased intracranial pressure and the direct cause of the compression symptoms. The symptoms of compression further than headache and mental dulness do not develop until the escape of cerebrospinal fluid, the narrowing of the

venous channels and the extrusion of the brain cease to compensate for the increase in the intracranial contents. As seen with fracture of the skull the symptoms of compression are apt to begin with localizing symptoms dependent on the site of the irritation and suggesting the site for any operative treatment. The localizing symptoms are soon masked by headache deepening into unconsciousness. The unconsciousness may come on very early if the intracranial pressure increases rapidly. The unconsciousness of compression may be superimposed on the unconsciousness due to concussion or there may be a period of consciousness described as the lucid interval, between the unconsciousness due to concussion and that due to compression. It is during this lucid interval that we look for the localizing symptoms that indicate the region of the injury. The time between the injury and the onset of the compression symptoms as well as the rate of development of the symptoms, suggest the cause of the compression whether hemorrhage or edema, and the source of the hemorrhage whether arterial or venous. The beginning manifest stage of compression is indicated by the distended superficial veins of the head and neck, distended veins of the retina, edema of the optic nerve found on ophthalmoscopic examination, a slow pulse beating fifty to sixty times a minute, a blood pressure from 160 to 200 millimeters of mercury, a disturbed sensorium with unconsciousness or at times restlessness and delirium. At the height of compression stage, the blood pressure reaches its maximum, perhaps 300 millimeters of mercury. The face becomes cyanotic, the veins prominent, the pulse slow, forty to fifty, full, bounding, with marked rhythmic variations of the Traube-Herring type. The respiration also shows rhythmic changes of the Cheyne Stokes type and is probably snoring. The size of the pupils of the eye is also subject to rhythmical change. The ophthalmoscope shows a choked disc. The stupor deepens or alternates with delirium varying with the pressure. The reflexes disappear. If the compression continues beyond the point of physiological tolerance there follows the stage of bulbar paralysis with marked oscillations in blood pressure, irregular heart action, rapid pulse, marked irregularities in respiration, deep coma, complete muscular relaxation and finally the blood pressure drops and respiration ceases. If the intracranial pressure can be relieved by appropriate cranial operation before the stage of paralysis, the earlier the better, recovery can be hoped for.

Laceration of the brain tissue also may be caused by the fracture. This is sometimes described, in order to make a euphonious triad with compression and concussion, as contusion of the brain. The laceration of the brain may be of very mild degree or crushing of large portions of the brain. The symptoms of the laceration depend on the region of the brain destroyed. Large masses of the brain tissue may be destroyed with extremely slight disturbance of cerebral function either at the time of the injury or subsequently. One of the most remarkable of such cases was described by Dr. Bigelow, professor of surgery at Harvard University in 1850, and has become a classic in medical case reports. A tamping iron over three feet long and an inch and a quarter in diameter was driven through a man's skull entering under the left zygoma passing through the orbit and emerging almost in the median line of the skull just in front of the coronal suture, so that a considerable portion of the brain was carried away. Immediately after the injury the patient had a slight convulsion but in a few minutes he answered questions. He was carried sitting erect, in an ox cart, some three-quarters of a mile, got out of the cart himself, walked up a long flight of stairs into the hall where his wounds were dressed. He retained his senses and memory perfectly and gave an intelligent and connected account of the accident. The blindness in the left eye from destruction of the optic nerve, and some slight irritability of temper were the only evidences of mental derangement in the subsequent years of his life. On the other hand it is well known that a needle prick in the medulla, if it passes through the respiratory center will cause instant death. Such a brain injury is demonstrated in the laboratory in the common pithing of the frog. Aside from the brain symptoms dependent on the particular nerve tracts destroyed there is always an associated edema which may be sufficient to lead to compression symptoms if there is no channel of escape for the edematous fluid. Such

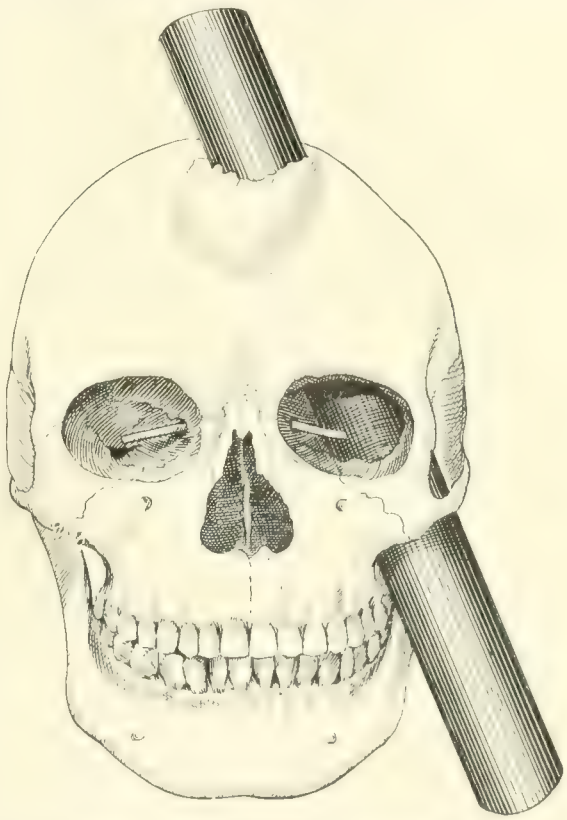

Fig. 3001.—A Tamping Iron (43 inches long and 1¼ inches in diameter) Driven Upward through the Skull. (Case of Dr. Bigelow.)

symptoms would come on late, several days after the injury; develop rapidly, and tend to clear up of themselves if there were no other factors to modify the course of the edema compression. The portion of the brain that is most liable to laceration, independent of the lacerations at the seat of fracture, is the tip of the temporal lobe and base of the frontal lobes. In fractures of the vault there is also not infrequently a contusion of the brain in the region diametrically opposite to the point of external injury the laceration being described as due to contrecoup. The lacerations give the same type of symptoms as concussion but are more marked and more prolonged. The nervous irritability is greater, the mental depression pronounced, the headache more persistent The treatment is primarily rest in bed until the headache is entirely gone, the pulse and the eyegrounds normal. It will probably be wise in the decided cases to do a subtemporal decompression to shorten the period of posttraumatic edema, and thus decrease the chances of late psychoses and neuroses.

The *treatment* of fracture of the skull is determined by the symptoms which occur in certain general

clinical classes. But at the outset it is wise to start with the intention of treating all severe injuries to the head as though a fracture were present until the presence of fracture has been excluded because many of the cases with apparently trivial symptoms following an injury to the head terminate in a most unexpected sudden death from late effects that have cast no warning shadow before their coming.

Clinically we divide the fractures of the skull into the two classes: fracture of the vertex and fracture of the base. The cases where both vertex and base are markedly involved are much more apt to go to the coroner than to the clinician. The extension of fissures from vertex to base are common and are classed as fractures of the base which is the more serious element.

In *fractures of the vertex* the simple, non-depressed fractures as a rule give the slightest symptoms. There is apt to be a history of a blow on the head following which there was a short period of unconsciousness: the patient regained consciousness and aside from headache had very little suggestion of trouble. Examination shows no loss of bony contour but distinct tenderness at the site of injury that can be sharply outlined in definite lines by pencil-point pressure. If there are several small fragments of bone there may be crepitus. An *x*-ray examination will usually outline the bony fragments. In the course of a few days there will show up ecchymoses at the site of the injury. There are no evidences of injury to the cranial nerves or to the brain as a whole. These patients we keep in bed and watch for development of symptoms of compression, recording the pulse and respiration rates at short intervals, and repeatedly examining the fundus of the eye. If no more symptoms develop at the end of a week or ten days, the patient can be let out of bed, watched for another week and discharged. If compression or irritative symptoms do develop an exploratory trephine is made at the site of injury or at the site of the irritative lesion, or if there are only symptoms of general compression a subtemporal decompression operation may become necessary.

If in the simple vertex fractures there is a depression in the bony contour, or if the *x*-ray plates clearly show a depressed fragment of bone whether of one plate or of both, then whether there are symptoms of brain irritation or not the bone over the depressed area should be exposed and the depressed fragment elevated or removed. Such an operation of itself tends to relieve any intracranial pressure.

In the compound fractures of the vertex there is the history of a more severe direct violence to the skull and usually a definite period of concussion unconsciousness, examination shows the loss of bony contour, and the large area of tenderness. There is apt to be bone crepitus and there may be fragments of bone evident in the wound. The wound bleeds pretty freely and if there has been a laceration of the dura also there is an escape of cerebrospinal fluid from the wound. If the brain has been badly lacerated there will probably be some brain tissue in the wound. In treatment of every such case the wound is rendered as nearly surgically clean as possible. The hair is shaved well away from the wound preferably all over the skull, and the skin painted with three per cent. iodine solution in alcohol. The brain tissue had best be treated with some milder antiseptic possibly boric acid. If it is possible to close the scalp over the brain and protect it from further exposure it will be wise to do so in order to prevent the chance of later infection. A drain down to but not through the dura is desirable. Open wounds leading to the brain are very apt to end in brain infection, abscess, or meningitis with a fatal outcome. Vaccine treatment for the infection is most strongly indicated.

Fractures of the base as a rule are much more serious than fractures of the vertex. They are apt to be found in patients giving a history of general compression of the skull, a fall striking the head on the ground, or the skull having been run over by a wagon or caught between two cars. Immediately following the injury the patient probably will be stunned, but will recover consciousness to a large extent after a few hours. Then during the lucid interval before symptoms of total compression set in there are some localizing symptoms from irritation of the special portion of the brain affected by the injury. These will soon be more or less masked by a gradually deepening unconsciousness due to the compression.

If the fracture is in the anterior fossa the signs dependent on the bony changes probably cannot be

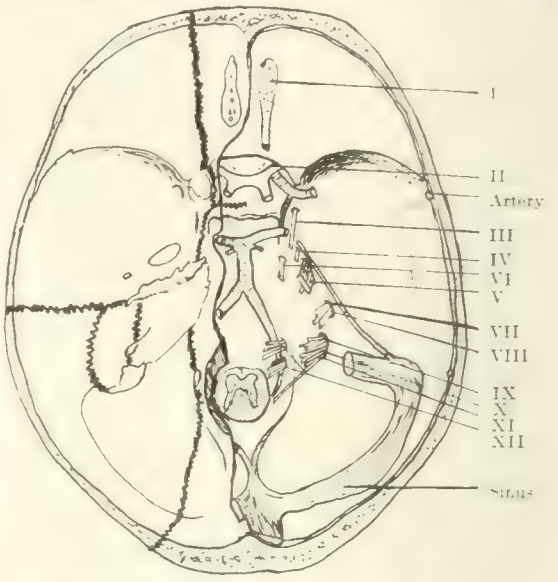

Fig. 3002.—Base of Skull. On the right side, dura, cranial nerves, middle meningeal artery, venous sinuses; on the left side sites of most common fracture.

elicited except for the *x*-ray examination which may show the line of fracture in the frontal bone. The blood-vessel injury is likely to be present and shown in the fractures of the cribriform plate by bleeding from the nose or mouth or vomiting of swallowed blood. There will be blood in the back of the orbit from fracture of the orbital plate of the frontal bone and this will show as an ecchymosis in the eyelids or as a subconjunctival hemorrhage. It may be sufficient to cause an exophthalmos. The nerves that are liable to injury are: the first giving impairment of smell and the second giving an impairment of vision. The only other sign significant of anterior fossa fracture that is dependent on intracranial injury is the escape of cerebrospinal fluid from the nose and mouth.

If the fracture is in the middle fossa where the majority of the fractures of the base are, there is usually a line of tenderness in the temporal fossa just in front of the ear, or in the region just behind the mastoid process. There may be a cracked pot sound on percussion. The *x*-ray almost always identifies the line of fracture. The evidence of injury to the blood-vessels is shown in the ecchymosis over the mastoid or in the temporal region, and hemorrhage from the mouth and nose if the tympanic membrane is not torn. If the membrane has been torn there will be bleeding from the external auditory canal. This bleeding is typically drop by drop but very persistent for hours or days and may well by associated with a leakage of cerebrospinal fluid. There may be intra-orbital hemorrhage at the same time with its evidences

in the eyelids and beneath the conjunctiva. In rare instances there will be pulsating exophthalmos. There will probably be irritation of some of the cranial nerves most probably the facial and auditory frequently also the motor nerves to the eye, the optic nerve, and some part of the trifacial.

If the fracture is in the posterior fossa there will probably be a history of great violence perhaps of a fall head first, or feet first landing with a rigid spine. Many of the cases are early fatal from the injury to the vital portions at the base of the brain in the posterior fossa. The unconsciousness of concussion is apt to go over into that of compression. On examination, we may elicit tenderness over the occiput. Possibly there will be a palpatable hematoma in the pharynx or free bleeding into the nose and mouth. There will probably be a late ecchymosis around the mastoid or along the deep muscles of the neck. The ninth, tenth, and eleventh cranial nerves are apt to be injured with associated interference with taste, with disturbances of circulation and respiration independent of compression symptoms, and of interference with the motility of the head.

The *treatment* of all the fractures of the base may be grouped together. No matter what the condition of the patient, if fracture of the base is suspected he should be kept in bed with the head elevated and immobilized by sandbags the room kept dark and quiet, and an ice coil applied to the shaved head. A cathartic preferably calomel should be given. During the stage of concussion when the patient is in shock he should be wrapped in warm blankets hot water bottles put to his feet, and careful watch kept on pulse, respiration, temperature, blood pressure, and eyegrounds. Focal symptoms should be looked for. A careful *x*-ray examination should be made with great caution not to injure the brain in the least. If it is feasible to roll the patient's bed into the *x*-ray room have the examination made without removing the patient from his bed. Morphine enough to keep the patient quiet should be a regular part of the treatment. Catheterization will probably be necessary. By such care compression may be avoided or lessened, but some degree of compression is almost sure to develop. If the symptoms of compression progress beyond the stage of compensation as shown by the distended and tortuous veins in the eyegrounds, edema of the optic nerve, a persistent rise in blood pressure that increases steadily while the pulse becomes unduly slow and excitement is persistent or alternates with unnatural sleep; if these develop then some decompression operation must be done promptly. If the fracture has been determined to be one of the anterior or middle fossa, there has probably been laceration of the middle meningeal artery, and the skull should be opened, the clot removed and the artery secured. It may be possible to do this through a trephine opening with its center above the middle of the zygoma on a level with the external angle of the orbit; or the trephine opening may have to be enlarged by rongeurs so as to get at the main trunk of the artery nearer to the base of the skull. It may be that the bleeding is from the posterior branch of the middle meningeal artery and then the trephine should be centered over a point above the posterior border of the mastoid on a line between the glabella and the occipital prominence. If such exploration fails to find the source of the compression aspiration through the dura should be made looking for subdural hemorrhage and a decompression opening left. If the compression symptoms persist operation on the opposite side of the skull should be made of a similar type. If the lesion was in the posterior fossa the operation should be made as a primary decompression operation in the occipital region. If no bleeding point can be identified gauze packing will control any venous leak or capillary oozing. If there is a compound fracture of the base irrigation of the ear, nose, and mouth as the symptoms indicate should be carried out, but great care taken not to irritate the nose and make the patient cough or sneeze as such a sudden action might be instantly fatal. Physiological salt solution should be used for the irrigation and if the site of the lesion can be seen a local application of a weak iodine solution in water might well be applied and then the nose or ear lightly packed with cotton. When in spite of this care taken to avoid infection meningitis develops suboccipital decompression and drainage should be tried and appropriate vaccine injected. The late developing localized brain abscess should of course be opened if possible. But any infection is very apt to be fatal. Another type of infection that is fairly likely to occur and makes our prognosis much less hopeful is a pneumonia which may develop when the patient seems to be doing best.

Certain *sequelæ* of skull fractures are of great surgical interest. Dependent on the loss of bone when the soft parts are intact there may be a hernia of the brain. Such a condition carries no danger to life and aside from its cosmetic effect is of little interest except that if the intracranial pressure is great and persistent there may be compression or even laceration of the brain at the hernial ring. Such should be treated by a larger decompression opening or another opening. When the soft parts over the bony defect are lacerated or gone and there is no open wound, the brain tissue is exposed and the danger of infection is great. The covering in of such an exposed brain area by a soft tissue flap should be done whenever practicable.

Dependent on the persistent irritation of the brain cells after a fracture there may develop nervous disturbances that take the form of epileptic seizures of a great variety of types, either motor or sensory or psychic, and may or may not have focal symptom. Such chronic irritation may be due to scars, adhesions, cysts, depressed bone, or other undetermined causes. The localization must take into consideration the fact that all such reflex symptoms are dependent on a complete nerve arc and the lesion in a sensory path may give rise to a motor response. Operative treatment in many such cases is justified but the removal of the cause cannot be promised even in the apparently clearest cases. And even after the cause has been found and removed the epileptic seizures may continue on account of the heightened sensibility of those particular nerve paths to all stimulation. In consequence we find that the late operations are very apt to be disappointing. Early operation to prevent the development of such seizures is much more desirable and a good argument in favor of elevating depressed fragments of bone, removal of blood clots, and accessible foreign bodies immediately after the injury, even though they may give no symptoms.

Dependent on the brain injury also are the cases of posttraumatic insanity, psychoses, and neuroses. These may come on within a day or two of the injury as an acute delirium followed by complete recovery after a very short period. Such cases need very little treatment more than gentle restraint so as to avoid letting the patient do further injury to his already irritated brain. The late neuroses can best be prevented by prolonged rest and quiet to overcome the shock of the injury. Late operations in such cases also are very likely to be disappointing.

Injuries to the Skull Contents.—With or without injury to the bones of the skull there may be an injury to the cranial contents. The injuries to the membranes covering the brain are insignificant except as associated with fracture of the skull or injury to the blood-vessels. Injury to the blood-vessels of the brain will produce an intracranial hemorrhage which may lie either between the dura and the bone called extradural, or between the dura and arachnoid called subdural hemorrhage.

The *extradural hemorrhage* is usually arterial from

the middle meningeal artery and caused by a fracture though it may occur after an injury without fracture. The characteristic common symptoms are those that appear after the stunning effect of the injury has been recovered from. Then in the free interval before compression has produced unconsciousness again we look for the irritative effects at the site of the hemorrhage. Most commonly the artery is injured toward the base of the brain near the Rolandic area causing twitchings of the forearm and then later paralysis beginning in the forearm. The compression is apt to extend over the area of the face and involve Broca's center giving an interference with speech. The pupil of the eye on the side of the hemorrhage is contracted in the early stages. As the compression from the hemorrhage increases there develops headache, vomiting, a deepening stupor with paralysis of the arm perhaps a hemiplegia. The pupil of the eye on the affected side is dilated as the compression symptoms increase. The treatment consists in locating the source of the bleeding and controlling the flow of the blood.

The *subdural hemorrhage* is more common after injury to the brain than after bony laceration of a blood-vessel. It is frequently seen with basal fracture due to the associated brain injury, and has its most common site at the tip of the temporal lobe and base of the frontal lobes. It is usually of venous origin more generally diffused through the open space between the dura and the brain and extends down the spinal canal so that lumbar puncture shows red blood cells. The intracranial pressure rises more rapidly and higher than in the extradural hemorrhage. There are no localizing symptoms. We consider subdural hemorrhage to be taking place in every case in which the unconsciousness persists without the lucid interval and compression symptoms follow directly on the shock of concussion. The treatment is primarily that of fracture of the base of the skull and as soon as the compression symptoms threaten compensation, decompression must be done, seeking through a temporal decompression wound and opening of the dura to withdraw the bloody cerebrospinal fluid and any clots that may be around the tips of the temporal lobes. A rubber wick drain through the dura may be a help, but a bilateral operation is often needed.

Concussion, compression, and laceration of the brain independent of fracture belong to the subject of the surgery of the brain.

Gunshot Wounds of the head when involving the scalp alone are like those of the rest of the body, and such we get fairly frequently in civil life with a soft small bullet or a ball with spent force. Here the bullet is apt to be flattened or deflected by the bone of the skull and cause little serious injury. In some cases there may be just enough energy in the bullet to cause a depressed fracture. In other cases the bullet enters the skull and flattens against or is deflected by the opposite wall of the skull without emerging. There are many instances of bullet wounds inflicted with suicidal intent where the bullet penetrates the skull outside of the brain box. One common type of such an injury is that starting from the ear and emerging from the temporal region near the external angle of the eye or in the orbit of the opposite side. Such an injury may cut the optic nerves and cause total blindness. The patient may have no other permanent injury than the mental instability that is so common after such accidents. Hard bullets with tremendous initial velocity from the modern army rifle inflict an entirely different type of penetrating wound of the skull. At close range the skull and the scalp will be torn to bits and the brain completely disorganized. At fifty yards the bullet penetrates the skull, leaving the scalp intact except for the wounds of entrance and exit, but the skull is comminuted throughout and brain tissue oozes from both scalp wounds. At 100 yards definite lines of fracture in the skull can be determined as occurring in meridians from pole of entrance to pole of exit and parallel circles of latitude with the poles as centers. At 1,000 yards there are left only the radial fissures from the poles of entrance and exit representing the meridian circles. At one mile there will be only the two clean-cut holes of entrance and exit and beyond a mile and a half the bullet probably fails to emerge from the skull. The wound of entrance into the skull shows a greater comminution of the inner table of the skull, the wound of exit shows greater comminution at the outer table.

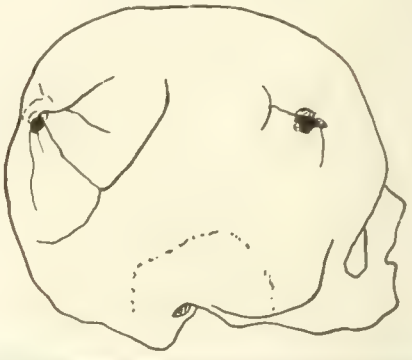

Fig. 3003.—Gunshot Fracture of the Vertex; wound of entrance more comminuted, wound of exit more chipping of external plate, fissures tending to run meridionally from wound to wound and in circles concentrically around wounds.

The *symptoms* of the gunshot wound are those of the bony deformity and the wounds in the scalp, the destruction of the brain and nerve tracts, the vessel injury dependent on the location of the fractures and the path of the bullet. The probability of sepsis is not as great as one would anticipate. The treatment consists in cleaning the wounds surgically, removing the fragments of bone, controlling the hemorrhage as far as possible, but making no effort to probe for the bullet or remove it, unless it is easily accessible. An *x*-ray examination locates the bullet or its parts. Aside from the immediate risks from the wound of the bullet there is a special liability to mental instability for the rest of the life of the patient, and not infrequently there are maniacal tendencies.

Injuries to the Head in the New-born Child have a few points of particular interest. Of the soft parts the normal edematous caput succedanum is present in practically every case. It appears on the presenting part and its location is determined by the external os of the cervix uteri. It is a soft swelling, does not fluctuate and disappears in a few days. In a few cases there is a cephalohematoma, usually a subpericranial effusion of blood the shape of which is determined by the adhesions of the pericranium to the underlying bone at the sutures. It usually does not appear until one or two days after birth and may be enlarged by the increased congestion of the head of crying or vomiting. It usually persists for ten to fourteen days before being absorbed. Deep fluctuation may be present. It needs no treatment unless it becomes infected, or absorption is much delayed. If it persists unduly long it may be desirable to make a clean incision turn out the blood clot and suture. If it becomes infected incision and drainage is imperative. In some infants at birth we see broad lines of more or less persistent erythema due to pressure of the head either on the pelvic brim or possibly by instruments used in delivery. These are rarely more than temporary markings.

Injury to the bones of the skull not infrequently takes the form of an indentation rather than a fracture, This may be spontaneously reduced by the elasticity of the skull in the course of a few days, or it may be reduced by manipulations. In some instances it may be desirable to correct the depression by operative measures in order to avoid the possible effects of persistent irritation.

Intracranial injury may follow a difficult labor whether instrumental or spontaneous. In such cases the extreme moulding of the head by overlapping the bones of the vertex not only causes laceration of the brain tissue but frequently also an intracranial hemorrhage. By the overlapping parietal bones the tributaries to the great longitudinal sinus are torn or in some cases the sinus itself is lacerated. Such hemorrhages are most frequent near the fissure of Rolando and limited to one side of the median line. The hemorrhage accounts for the retarded spontaneous respiration and asphyxia. Later the breathing is irregular, perhaps rhythmically so, the pulse is slow and the pupils unequal. Nursing is not satisfactory so that the infant may have to be fed by hand. The intracranial pressure is shown by the tense fontanelles and the dilated vessels in the scalp and in the eyegrounds. Twitchings and convulsions may be present. The treatment as in the other case of intracranial hemorrhage should be by the removal of the clot as soon as compression shows itself. In operating on the infant especial care must be taken to maintain the body temperature of the patient and to sedulously avoid all blood loss. The loss of an ounce in an infant corresponds weight for weight with the loss of more than a pint in an adult. If the blood clot is not removed and the infant lives the chances are that some late effects will appear from the adhesions, thickened meninges, or unabsorbed blood clot. It has been suggested that many of the cases of apparently idiopathic epilepsy are due to a birth injury that escaped notice, and that porencephalus follows a brain clot.

Diagnosis of Head Injuries.—When we see for the first time a patient suspected of having had an injury to the head we have to determine what the cause of the symptoms is and, if they are due to an injury, how far the condition has progressed. If the patient is in coma we think of several conditions which have to be differentiated: First, the drug effects such as those from alcohol or opium; second, the toxemias such as those from uremia, diabetes, and intestinal autointoxication; third, the organic conditions from inflammation such as meningitis in its many forms, traumatism with its concussion, compression or laceration of the brain; and then abscess, tumor, and apoplexy, and finally we must think of hysteria. The differential diagnosis between these conditions is not always easy, but a systematic examination will help us.

In a *systematic examination* of a patient suspected of having an injury to the head we get first of all a *history* of the previous health of the patient which might account for toxemias such as uremia, diabetic or intestinal intoxication; we inquire for the possibilities of drug effects such as those of alcohol or opium, and other functional disturbances such as hysteria. Then in the organic conditions in addition to those from traumatism we seek a history that would suggest apoplexy, brain abscess, brain tumor or some of the forms of meningitis. In the cases where we get a history of trauma we wish to know the time that has elapsed since the injury and the nature of the injury, whether a fall, a blow, a crush, whether the injury followed contact over a large surface of the skull or was applied at a small point and what the degree of pressure was. In the physical examination we note primarily the *age* of the patient; if a child the skull is apt to bend rather than to break, there could be no fractures of the inner table alone, and fractures of the base are comparatively rare. On the other hand, if the patient is advanced in years we have to consider the greater probability of atheromatous arteries and the greater chance of hemorrhage. We note in the general condition of the patient the condition of the arteries, the heart, the urine. We pay special attention to the question of unconsciousness, noting the presence of mental depression and its degree, whether it appeared immediately after the injury or developed later or whether it appeared early, cleared up and after a lucid interval developed again. Most important of all is the progress of the unconsciousness, whether it is increasing in depth toward unrousable coma, or becoming lighter toward a mere clouded mentality. We next note the degree of shock, the temperature of the skin, and the presence of perspiration. A subnormal body temperature we expect to find in the shock of concussion, but it may also be due to other causes such as alcohol or opium poisoning; an elevated body temperature to 99° or 100° suggests some intracranial lesion. If the temperature rises much above 100° laceration of the brain is very probable. Vomiting not infrequently is present and the material vomited may suggest the type of toxemia, or a compound fracture of the base if it contains blood. The dejections and urination may be absent from poisoning, kidney trouble, or paralysis; they may be involuntary from great depression of the nervous system. In taking the pulse we note not merely the rate and regularity but any rhythmical changes, especially in the blood pressure. A careful blood-pressure study is of the greatest value to determine the progress of the intracranial condition. Blood-pressure readings recorded every fifteen minutes for the first few hours and later at perhaps longer intervals, depending on the progress of the symptoms, will be most helpful. Records of the respiration are also of great value noting depth, rate, and rhythmic variations. Repeated observations on the respiration are about as valuable as those of the blood pressure and pulse.

The *local examination of the head* is that to which we give great attention. On inspection we note the visible wounds of the scalp, orbit, ear, nose, and mouth, the blood marks from the wounds, the quantity and duration of any bleeding. We seek ecchymoses at the site of injury and at distant points around the head and neck, in the eyelids and under the conjunctiva. We note the dilatation of the blood-vessels of the face, neck, and eyelids. We look for evidences of paralysis of the muscles of the eyes, face, neck, and tongue. We note the size of the pupils, their reaction to light and accommodation, and their variations in size. We look for the escape of cerebrospinal fluid from any wound about the head.

On palpation we seek changes in the bony contour, tenderness over the skull both at the vertex and at the base as far as it can be palpated, over the face, jaw and temperomaxillary joint. We feel for crepitus between bony fragments.

We test the sensations of the face to touch, of each nostril for smell, of each eye for vision, of each side of the tongue for taste at the tip, side, and base. We test each ear for hearing. We examine the fundus of the eye for dilated veins, edema of the papilla or choked disc. We make an *x*-ray examination of the entire skull. We make a lumbar puncture to determine the intraspinal pressure and the presence of blood or pus cells in the cerebrospinal fluid. In case of an infection we may get from this fluid bacteria for an autogenous vaccine for the treatment.

We examine the rest of the body for evidences of cerebral disturbances as shown by muscular twitchings, or paralyses in arm, leg, and trunk, and for loss of sensation. We note the condition of the reflexes as showing the general control from the brain.

In our examination of the rest of the body we also keep in mind other injuries that have been associated with those to the head, and also the possibility that

injuries to the other parts of the body may be sufficient to account for some of the symptoms attributed to the head injury. For instance, a blow over the solar plexus may closely simulate concussion of the brain.

After completing our primary examination we must always remember that further careful watching is necessary in every case. The condition that seems trivial at the first examination may be entirely changed in a few hours and no case with an evident cranial injury should be allowed out of observation for at least ten days and preferably repeated observations should be kept up for a month or more. In regard to prognosis, as Hippocrates taught, no injury to the head is too slight to be despised, or too severe to be despaired of.

TRUMAN ABBE.

Headache.—Headache is a frequent manifestation of the most varied disorders of the nervous system and of other organs. Being merely a symptom of so many different morbid states, it cannot be consistently characterized or described as a disease, although it is occasionally of such a nature as to possess the significance of an independent affection.

It may be so fleeting or transient as to be more or less ignored by the patient, or it may attain such a degree of severity or persistency as to lead the sufferer to seek medical advice. Familiarity with its various forms is essential, and it is necessary always to bear in mind that headache is a frequent accompaniment of many constitutional diseases. Hence a description and classification of headache with suggestions as to the means of determining its causation must prove of great practical value. According to many modern observers, we know almost nothing of the structures in which the pain of headache is felt or of the mechanism of its production. As the meninges, especially the dura and a large area of the cranium, receive their sensory supply from the terminal sensory branches of the trigeminus, and as the meninges are also supplied by branches of the sympathetic nerve, it is reasonable to assume that headache is the result of direct or indirect irritation of these nerves.

Psychical disturbances, in the form of depressing emotions such as grief, worry, fright, etc., often produce headache; in such instances it must be due to processes originating in the higher cerebral centers through which superficial pain is perceived. Headache must not be confounded with true neuralgia affecting the occipital or supraorbital nerves in which the pain is paroxysmal in character and directly limited to the course of the nerve and its distribution. The idea that the location of the pain in any particular region of the head is always directly related to some special underlying or adjacent pathological process (excepting pericranial inflammation), has not been substantiated by clinical experience.*

No definite rules can be laid down in regard to this matter that will apply in every case. It may be said, however, after perusal of the histories and observation of a large number of cases, that pain located at certain parts of the head occurs more often in this or that condition of disease. Such information, nevertheless, may prove valuable in suggesting certain lines of inquiry when found associated with other symptoms.

The headache may be confined to the forehead, to the vertex, the parietal, temporal, or occipital region on one or both sides; it may be unilateral as in migraine, or it may affect the entire head, and is then described as general or diffused, or it may occur in various combinations.

Patients usually describe the pain in the head, which frequently dominates all other symptoms, as acute, sharp, throbbing, darting, dull ache, boring, burning, stabbing, etc. It may be transient, paroxysmal, periodical, or continuous, and may vary in degree and location from time to time. As pain is a subjective symptom we can judge of its degree only by the *total ensemble* of the individual and by its association with unmistakable physiognomical expressions and physical manifestations.

"Traditional psychology may be said to regard pain as a feeling, *i.e.* a purely mental state or condition, with or more frequently without a physical basis in the nervous system. Physicians do not place much confidence in the patient's statement of the quality or character of the pain, largely because patients have not words, nor experience to prompt the words, in which to describe their pains. The description of pain by a patient seems to be directly proportional to (1) liveliness of imagination, (2) vocabulary, (3) experience" (Witmer). The description is often materially enhanced by the patient's gestures.

Headache, for all practical purposes, may be divided into two classes—functional and organic.* The so-called functional forms of headache are by far the more frequent, and include those resulting from various constitutional or psychical disorders, and from causes not situated in the skull or cranial cavity, excepting the disturbances of special-sense organs, such as the eye, ear, and nose, and dental caries. Some special forms of disturbance of the cerebral circulation may also be placed in this category.

The organic form includes all types of intracranial disease, whether vascular, meningeal, or cerebral, and diseases of the cranial bones.

The functional forms of headache may be classified and subdivided as follow:

TOXEMIC.	1. Retained excrementitious substances. 2. Products of defective metabolism. 3. Infectious germs or their toxins. 4. Various drugs. 5. Graves' disease.
NEUROPATHIC.	1. Neurasthenia. 2. Hysteria. 3. Epilepsy.
CIRCULATORY.	1. Hyperemia. 2. Anemia.
HEADACHE CAUSED BY OR ASSOCIATED WITH VARIOUS DISORDERS.	1. Ocular. 2. Auditory. 3. Nasopharygeal. 4. Dental. 5. Gastric. 6. Uterine. 7. Sexual.
MIGRAINE.	
ORGANIC.	1. Intracranial tumor. 2. Cerebral abscess. 3. Leptomeningitis. 4. Pachymeningitis. 5. Syphilis. 6. Vascular disease. 7. Encephalitis. 8. Mastoid disease and sinus thrombosis. 9. Disease of the cranial bones. 10. Diseases of the frontal sinus. 11. Caries of the cervical vertebræ. 12. Acromegaly. 13. Spinal-cord disease.

TOXEMIC HEADACHE.—In which the blood is contaminated by various deleterious agents.

1. *Retained Excrementitious Substances.*—(The absorption of decomposition and fermentation prod-

* Head in his work on "Referred Pain" has endeavored to prove the existence of certain sensitive areas on the scalp in their relation to diseases of internal organs.

* While it must be admitted that this classification is somewhat arbitrary and unscientific, yet, in my experience and that of many others, it has proved a valuable guide and working basis in clinical observation.

ucts developed in the alimentary canal, or the reabsorption of retained excrementitious substances.) (*a*) Constipation. (*b*) Intestinal indigestion. (*c*) Gastric indigestion. (*d*) Uremia.

(*a*) *Constipation.*—In a very large majority of instances in which headache is complained of, it is due to toxemia resulting either from constipation, or from intestinal or gastric indigestion. The clinical fact has long been established that autointoxication of intestinal origin plays an important rôle in the production of headache, migraine, and vertigo, but such symptoms are evidently more or less dependent upon individual susceptibility. Constipation is not incompatible with apparent health, for some persons may be constipated for a week or more at a time without any complaint of digestive trouble or headache. For this reason, the objection has often been made to the hypothesis of autointoxication of fecal origin. On the other hand, Bouchard, who has made a special study of this subject, believes that constipation should be regarded as a protection against intoxication, and says: "it supposes that all that is absorbable has been absorbed, the aqueous part with what was held in solution." The lengthiest argument, however, will not controvert the familiar fact that thorough purgation causes the rapid disappearance of the headache and associated symptoms in most cases of this character.

In these patients the headache is usually located in the frontal region, but is often diffused over the entire head. As a rule, it is not constant, and may or may not be associated with gaseous eructations.

In some it is accompanied by morbid somnolence during the day and heavy sleep at night, while in others insomnia is complained of. Occasional attacks of vertigo may also occur.

(*b*) Intestinal indigestion, with or without constipation, is more frequently productive of headache from intestinal toxemia than as a supposedly reflex cause. The urine is often of high specific gravity and may contain an excess of indoxyl.

(*c*) Gastric Indigestion.—It would seem that gastric indigestion, on the other hand (although in some instances occasioning toxic absorption), is more likely to produce headache by reflex irritation through the pneumogastric nerve from fermentation of food and gaseous distention of the stomach. Thus, headache, possibly due to both causes, is frequently an accompaniment of dilatation of the stomach on account of the anomalous fermentations that are the consequences of it. The location of the headache is usually supraorbital or frontal.

(*d*) Uremia.—Headache due to renal disease is of very common occurrence. Two forms are found in nephritic subjects—*uremic* and *congestive*. Either one or both may be present in the same patient. The *uremic* form is due to the retention in the circulation of excrementitious products, and may manifest itself in any type of kidney disease, whether acute or chronic. The pain is ordinarily situated in the occipital region, extending to the neck. It may or may not be associated with somnolence, nausea, or vomiting, etc., according to the degree of damage to the kidneys and arterial system. In some cases the headache may be accompanied by vomiting, vertigo, and optic neuritis, thus simulating the general cerebral symptoms of brain tumor. The *congestive* form arises in consequence of disturbed cerebral circulation in the presence of cirrhotic kidneys, with arteriosclerosis, cardiac hypertrophy, and increased arterial tension. (See "Circulatory" form of headache.)

Puerperal Eclampsia.—Headache which is at times persistent and severe is often a premonitory symptom of a convulsive attack in this affection, and may be associated with delirium, excessive somnolence, mental hebetude, or insomnia. Edema of the face and extremities is often present. This condition is generally regarded as acute renal disease of pregnancy, the headache and other symptoms being ascribed to some form of toxemia not yet determined. Unless the urine is carefully analyzed, and the functioning power of the kidneys ascertained beyond question, the uremic form of headache will often pass unrecognized, thus leading to unexpected and serious consequences.

2. *Products of Defective Metabolism.* (*a*) Rheumatism. (*b*) Gout. (*c*) Diabetes.

(*a*) Rheumatism.—There are three forms of headache which may occur in rheumatic subjects:

1. Due to some form of defective metabolism or intestinal toxemia, the headache generally being diffused and similar to that occurring in other forms of toxemia.

2. A true muscular rheumatism or myositis located in the scalp and affecting principally the occipitofrontalis muscle and its aponeurosis. The pain is increased by active or passive movement of this muscle, and it is common to obtain a history of other attacks of muscular rheumatism, affecting different parts of the body. These patients may also have suffered from acute or subacute articular rheumatism. The attack may last for from a few hours to several weeks. Like other forms of muscular rheumatism, it is brought about by exposure to cold. One of the worst cases seen by the writer occurred in a rheumatic subject after bathing the head in cold water, and then sitting at an open window for a half-hour or more.

3. Nodular or Induration Headache.—This form of headache has not been sufficiently recognized by the medical profession. It is more common in women of middle age. As a rule, the pain is severe and persistent, beginning in the occiput or nape of the neck, at times involving the entire head, and often radiating toward the back and shoulders. Tender nodules or infiltrations varying from the size of a millet seed to that of an almond are found distributed in the subcutaneous connective tissue and muscles of the scalp. They are usually demonstrable in the tendinous insertion of the occipitofrontalis and also in the trapezius and sternocleidomastoid muscles. The principal treatment which ultimately gives complete relief is frequent and systematic local massage. The use of the sinusoidal current has also proved efficacious.

(*b*) Gout.—Headache is frequent in gouty subjects. It may be due to toxic products of defective oxidation, or the result of vascular disease affecting the cerebral circulation. It is not unusually accompanied by interstitial changes in the kidneys. Gout, it is claimed, is merely a hypothetical condition and presupposes an excess of uric acid in the general circulation. The headache and the irregular symptom-complex often described as lithemia is an atypical form of gout. There is more often a sense of pressure and fulness about the head than actual pain. Haig has called special attention to the association of such symptoms with retention of uric acid in the system. It is now well established that the headache, aberrant neuralgic pains, slight stiffness in the joints, and occasional attacks of acute gout, etc., arise in connection with defective metabolism. The most essential etiological factor is deficient oxidation resulting from overindulgence in unsuitable food and overdrinking, and the lack of sufficient physical exercise.

(*c*) Diabetes.—Headache occurring in diabetics is often accompained by hebetude and depression of spirits. As a premonitory symptom of diabetic coma, it is soon followed by delirium and dyspnea. The prevailing theory is that the latter form of intoxication is due to the presence of acetone in the general circulation.

3. *Infectious Germs or their Toxins.*—(*a*) Acute infectious diseases. Headache is frequently a prominent symptom in the early period of all acute infectious diseases. It is usually described by the patient as a generalized or frontal headache. As an initial symptom of typhoid fever, it is sometimes so severe and persistent as to demand special attention. The pain is often located in the occiput and back of the neck.

It may be accompanied by photophobia, retraction of the head, and muscular twitching, thus simulating meningitis. In the early stage of smallpox, the intense frontal headache is accompanied by pains in the back and limbs. The same may be said of the grippe. General headache also occurs in the early period of acute croupous pneumonia and may simulate meningitis until the lung trouble has clearly developed. During the febrile stage of malarial intermittent or remittent fever, violent headache is often present. In general, it may be said that headache occurs in all conditions accompanied by fever. As a routine practice, the temperature should be taken in every case of acute headache. The character and frequency of the pulse, and the presence of fever are always suggestive of the probably infectious or inflammatory origin of the trouble.

4. *Various Drugs.*—Nitrite of amyl and nitroglycerin will be mentioned under the head of "Disturbances of the Intracranial Circulation."

Alcohol.—Headache is often due to acute or chronic alcoholic poisoning. The nervous system is at times so sensitive that a small dose of alcohol may produce violent but transient general headache of a congestive type. Very frequently, after large doses sufficient to produce heavy sleep, the individual awakes with a severe headache the result of such indiscretion. This picture is unfortunately so familiar that it requires no further elaboration. Chronic alcoholic poisoning is often the cause of daily or constant headache. The headache is commonly due to a combination of causes, such as toxemia, interference with the digestive processes, and cerebral arteriosclerosis. It is often accompanied by cirrhotic changes in the liver and kidneys, and by many of the attendant phenomena of these conditions.

Tobacco.—The habitual and excessive use of tobacco may be the indirect cause of headache, through its deleterious action on the digestive organs, its interference with the cardiac rhythm and the cerebral circulation, and the ultimate production of neurasthenia.

Coffee.—In some individuals the injudicious and excessive use of coffee is productive of headache and a sense of fulness in the head.

Lead.—Headache due to the toxic action of lead is a comparatively rare symptom. In some cases of chronic lead poisoning, however, headache does occur, and its cause must be recognized. It is probably due to the direct action of the lead on the cerebral nerve centers, or indirectly through the production of pathological conditions in the liver and kidneys. A rare form of saturnism, which is productive of serious cerebral symptoms and which may terminate fatally, is known as "lead encephalopathy." In this condition the headache is usually severe, and is associated with vertigo and bilateral optic neuritis (which may end in complete blindness) and a series of symptoms simulating the presence of an intracranial tumor. The more severe forms terminate in convulsions, delirium, and coma.

5. *Graves' Disease.*—Recent studies regarding the pathogeny of the symptom group known as Graves' disease lead us to assume that the condition is due to hyperthyroidism from hypersecretion of the thyroid gland, which is often preceded by sudden or prolonged depressing emotions. Headache is not common in this affection, but it is sometimes a troublesome symptom, and may be confined to one side. It is occasionally accompanied by a sense of throbbing in the head, a pulsating noise in the ears, and transient vertigo. The rapid action of the heart and cardiac palpitation, the presence of thyroid enlargement, exophthalmos, tremor and excessive perspiration, will lead to a correct diagnosis.

Neuropathic Headache.—1. *Neurasthenia.*—Headache is often an important symptom in neurasthenia, but it is not present in all cases. As a rule it is not general, but is commonly located in the frontal or occipital region, and is often accompanied by occasional vertigo and muscæ volitantes. The headache, which is usually slight in degree, is either continuous or occurs at brief intervals. In the majority of neurasthenics actual pain is not complained of, but the sensations in the head are described as the feeling of "a constricting band about the forehead," "fulness in the head" as if there was "something pressing from within against the skull," etc. Frequently it is a sensation of weight or numbness, and occasionally of throbbing. The headache and other sensations increase after fatigue, and are often diminished by rest. Difficulty in concentrating the attention is often present. As a result of these varied forms of cephalic paresthesiæ, such patients are inclined more or less to indulge in excessive introspection. They often become morbid and apprehensive, dreading the possibility of a brain tumor or other serious cerebral disease. All of these symptoms are modified in proportion to the attention given them by the patient. The presence of other signs of neurasthenia, their development, or increase through mental effort or emotional excitement, and the absence of evidence of organic cerebral disease, make the diagnosis clear.

2. *Hysteria.*—Headache that is confined to a small spot, which has for many years been described as "clavus," is comparatively unusual in this country, and occurs most frequently among the premonitory symptoms of convulsive hysteria. The scalp is sometimes so sensitive that the slightest touch is not tolerated without wincing. In the majority of cases of hysteria, however, the headache corresponds with that of neurasthenia. It may be limited to one side and thus simulate migraine. In some instances, it may be characterized as a veritable psychalgia. The peculiar character of the headache, its dependence upon the momentary psychical condition of the patient, its rapid disappearance or variation in degree, the favorable influence of suggestion or diversion, and its occasional association with other signs of hysteria (paralysis, spasm, convulsive attacks, disturbances of sensibility, etc.) enable us to make a correct diagnosis. The stigmata of hysteria are not always present.

3. *Epilepsy.*—While headache cannot be regarded as a symptom of epilepsy, its occurrence is at times of great importance in the diagnosis of obscure cases. An attack of *grand mal* is often followed by severe general headache which may last for several hours or days. This fact is of value in interpreting the cause of the headache when it is mentioned as occurring in the early morning on awaking. It is at times indicative of a nocturnal epileptic attack, and the diagnosis is positive when such headache is associated with soreness of the muscles and joints of the extremities, a bitten tongue or mucous membrane of the cheek, and wetting of the bed.

Circulatory Headache.—Headache due to disturbance of the cerebral circulation in the absence of organic intracranial disease.

Hyperemia.—Headache is at times the result of hyperemia or congestion of the intracranial circulation. It may also be occasioned by cerebral anæmia. When it is due to increased arterial supply it is called *active*. If it is caused by obstruction of the venous circulation, it is termed *passive*.

(*a*) Active Hyperemia.—This condition has been described as "cephalalgia vasomotoria" by Eulenburg, and is due to paralysis of the vasoconstrictors permitting of distention of the vessels. It may be either acute or chronic, but it is most frequently acute. As a rule, in the severe cases, it is accompanied by throbbing and pulsating general headache, vertigo, tinnitus, muscæ volitantes, photopsia, insomnia, mental confusion, and delirium, all of which are made worse by lowering the head. There may also be

photophobia and general hyperesthesia. The face and scalp are red, and the conjunctivæ injected. There are fulness and throbbing of the temporal arteries, and contracted pupils. The pulse is full, and may be either slow or increased in frequency, with high systolic blood pressure as measured by the sphygmomanometer. Occasionally there is a slight rise of temperature. In some individuals, such attacks occur periodically. The severe forms of this condition are fortunately rare. In the milder degrees it is not uncommon, but the diagnosis may at first be doubtful. Somewhat similar phenomena occasionally occur in the early stage of acute leptomeningitis of the convexity. There may be considerable variation in the intensity of the process, hence the above described symptom-complex is manifested in varying degrees. The condition is usually due to mental overwork, emotional disturbances, alcoholism, excessive use of tobacco, onanism, and injuries to the head. It occasionally occurs as a sequel of sunstroke, and from sudden suppression of menstruation in plethoric women.

The writer has in several instances witnessed a similar but slightly modified array of symptoms occur periodically in young women after removal of both ovaries. A prototype of this group of symptoms can be produced by the administration of various drugs, such as nitrite of amyl, nitroglycerin, etc.

(*b*) Passive Hyperemia.—Venous hyperemia of the cerebral vessels is an important cause of habitual headache. It may be either acute or chronic, but is most frequently chronic. The pain is of a dull character, and is often accompanied by a sensation of fulness and heaviness in the head. The face and ears may be slightly cyanotic in the more pronounced cases. The attacks also vary in degree, the minor forms not being uncommon. Passive cerebral congestion is generally caused by mechanical hindrance to the return of blood from the head. Thus, it results from growths in the neck making pressure on the jugular veins, cardiac disease, pulmonary emphysema, and persistent cough, as in pertussis. It may also be produced by a tight collar, or by continuous flexion of the head. The headache and other symptoms are aggravated by straining at stool, coughing, sneezing, stooping, or muscular effort.

Anemia.—Anemia of the brain, as a rule, is a part of a general condition of anemia and malnutrition. It may be the result of arteriosclerosis including disease of the coronary arteries. Whether the general anemia be of a chlorotic nature or from loss of blood, it is almost always accompanied by headache. The condition of cerebral anemia in which headache occurs, is generally of the chronic form. The headache may be frontal, vertical, or diffused, and is commonly of a dull character. It is often associated with attacks of syncope, tinnitus, dizziness, incapacity for mental work, depression, and irritability. The pupils are usually dilated. The headache often diminishes or subsides when the patient assumes the recumbent position with the head low.

Headache Caused by, or Associated with, Various Disorders: (Ocular; Auditory; Nasopharyngeal; Dental; Gastric; Uterine; or Sexual). 1. *Ocular.*—Ocular defects, such as errors of refraction and insufficiency of the ocular muscles, are a common source of headache. The two conditions may be found in various combinations. It has been claimed that fully sixty per cent. of functional headaches due to errors of refraction are caused by astigmatism alone, or in conjunction with other forms of ametropia (De Schweinitz). The headache is produced by strain on the ciliary muscles, and frequently arises in connection with hypermetropic astigmatism. The pain may be situated in any part of the head, but it is most frequently located in the supraorbital region. It may be persistent in character, and is often aggravated by using the eyes. It is relieved temporarily by the instillation of atropine, which paralyzes the ciliary muscles, or permanently, by wearing suitable glasses.

Headache caused by insufficiency of the ocular muscles may affect any portion of the cranium, but is often located in the occipital region. It may immediately follow the use of the eyes, but usually this is not the case, the pain occurring at irregular intervals. At times it may develop into a typical attack of migraine, and is often associated with symptoms of neurasthenia. The claims of certain writers, that the lack of balance in the action of the muscles of both eyes is a prolific cause of headache and various forms of nervous disease, have certainly been much exaggerated. The headache arises as a result of repeated or continuous efforts to obtain and preserve binocular single vision. It is a fact well known to all ophthalmologists that so-called ocular headache does not occur in patients in whom there is a congenital or acquired absence of binocular vision, as such patients are known habitually to suppress the image in one eye. Hence, the causative element of "effort at binocular fixation" is negligible under such circumstances. This occurs with high degrees of strabismus; paralysis of ocular muscles; when vision is greatly diminished or lost in one eye; and when there is considerable difference in the refraction of the two eyes. When headache occurs in such people it is invariably due to some other cause. The writer knows of a patient with ocular headache from muscular trouble in whom the pain entirely disappeared after the accidental destruction of one eye.

The improved methods in the examination of the power and action of the ocular muscles, introduced within recent years, have led to a more accurate and thorough study of these conditions. Curiously enough, the muscular troubles which occasion the greatest amount of discomfort to the patient at times produce no evident changes in the gross appearance of the eyes. Hence it is only after the most careful and painstaking investigation that they can be discovered and rectified. This is accomplished either by the use of suitable lenses to neutralize any existing refractive anomaly, and thus indirectly influence muscular action, or by surgical operation, or both. There must be a peculiar individual predisposition to headache, for there are persons who have both muscular and refractive anomalies without any symptoms of headache.

Headache often results from inflammatory eye troubles such as iritis, glaucoma, etc. In iritis, the pain is generally supraorbital, but may extend to the whole side of the head. Acute inflammatory glaucoma is accompanied by violent pain radiating through the head from the eye. The headache occurring in these conditions cannot be classified as of reflex origin. It is due to direct inflammation of the ophthalmic division of the trigeminus, and increased intraocular tensions.

2. *Auditory.*—Impacted cerumen has in rare instances been the supposed cause of headache. In middle-ear disease, the headache affects the vertex or is situated in the temporal or mastoid region on the same side.

3. *Nasopharyngeal.*—Any of the following pathological processes may occasion headache: adenoids in the nasopharynx; polypoid obstruction to nasal breathing; lesions of the turbinated bones, especially of the middle and posterior parts of the inferior turbinate; spurs from the nasal septum; or intranasal synechiæ. Hence, headache is not an uncommon condition in mouth-breathers. The pain is ordinarily located in the temporal region or the forehead. When such abnormities are removed the headache has often been known to disappear.

4. *Dental.*—Caries of the teeth in the upper jaw is an occasional cause of headache.

5. *Gastric.*—See the section on Gastric Indigestion.

Headache Superinduced by Hunger.—In some individuals headache arises as a result of hunger. A delay of a few hours in the time of the customary meal causes general discomfort and headache which disappear at once when food is taken. This form of headache is probably produced through irritation reflected from the gastric mucosa or from temporary impoverishment of the blood diminishing the nutrition of the cerebral sensory centers. Such individuals often manifest a peculiar susceptibility to headache from other causes especially migraine.

6. *Uterine;* 7. *Sexual.*—Headache occurring in patients with uterine or ovarian disease should not be looked upon as a symptom of reflex origin. It is merely one of many phenomena associated with a neurasthenic condition which so frequently accompanies intrapelvic disease in women. The headache frequently affects the vertex but is more often general, and is at times accompanied by tenderness of the scalp. Other causes are usually operative independently of any local uterine lesion. The morbid self-consciousness developed in many women who have or think they have uterine or ovarian disease, is often sufficient in itself to engender a depressive form of neurasthenia. The same may be said, *mutatis mutandis,* of affections of the male genito-urinary organs.

According to Head (Allbutt and Rolleston's "System of Medicine," vol. vii., p. 749) headache may be secondary to disease of the organs within the thorax and abdomen. The pains in the head may be very slight, but are always associated with scalp tenderness in certain areas. The degree to which these pains in the head intrude on the patient's consciousness varies greatly. Thus, sometimes he is quite unaware that the scalp is tender, and the associated tenderness is discovered only by examination. He may, however, complain of headache which leaves behind it a feeling of intense soreness.

Migraine. *Definition.*—This affection has also been termed "sick headache," "hemicrania," and "paroxysmal headache." It is a periodical neurosis occurring most frequently in women, and is characterized by paroxysmal attacks of severe pain usually confined to one side of the head, chiefly in the course of the fifth nerve. At times it is preceded by a variety of transient visual disturbances and paresthesiæ, and followed by nausea and vomiting.

Symptoms.—The headache does not arise suddenly, but is generally preceded by premonitory symptoms, such as vague indisposition, restless sleep, irritability, depression of spirits, somnolence, sensation of fulness in the head, slight dizziness, etc., and, later, transient ocular symptoms may develop. The headache is dull and slight at first, but gradually reaches such intensity that it is often described as unendurable, and the patient is frequently obliged to go to bed. During the attack all of the senses become more acute, and there is general hyperesthesia, the sufferer being disturbed by bright light or the slightest sound. The temperature is normal, and the pulse is either slightly accelerated or slow. Sometimes, on the affected side, the face is flushed and hot, the conjunctiva injected, the pupil contracted, and there is strong pulsation of the arteries; or the face is pale and the pupil dilated. But such phenomena are by no means constant; in fact they are quite rare. They usually alternate during the attack and are most frequently bilateral. The former has been interpreted as due to sympathetic vasomotor paralysis (angioparalytic), and the latter as being due to vasomotor spasm (angiospastic). Too much stress has been laid by some writers upon the value of such manifestations. They are so uncertain and variable that as a rule they are of no special clinical significance. The pain is usually confined to one side of the head. It may, however, affect either side alternately, or both sides may become involved at the same time, the pain varying in degree on the two sides. The left side is more frequently affected. At one time it may have its greatest intensity in the forehead, and at another time it may be situated in the occipital region. Nausea and vomiting generally take place either during the early part of the attack or toward the end. In some patients vomiting is absent. Polyuria occasionally occurs at the termination of the attack. When the pain subsides, sleep follows, and the patient awakes free from discomfort. The headache may last for from several hours to three or four days or longer. Ocular symptoms constitute a prominent feature in a certain number of cases, but they do not occur in every attack. In the most common type of migraine they are entirely absent. The visual disturbances occur in the form of photophobia, blurring of vision, bright lights, vibrating or luminous sensations which commence over a small area and gradually widen out, the flashing increasing in intensity and often assuming a zigzag shape like the outline of fortifications (scotoma scintillans), hemianopsia, and transient amblyopia or blindness. This type has often been termed "ophthalmic migraine."

Other abnormal sensations are also complained of, such as disturbed sensation in the extremities, numbness and tingling in the skin, as well as partial aphasia. The eye symptoms and paresthesiæ when present almost invariably precede the headache (just as certain auræ precede an attack of epilepsy), and last for from a few minutes to half an hour. In rare instances, such sensory phenomena occur paroxysmally without the headache.

Etiology.—It is pre-eminently an inherited disease. The constitutional peculiarity which predisposes certain people to migraine is not clearly understood. That some persistent pathological condition must exist is quite evident. Many of the so-called reflex causes, such as uterine and menstrual disorders, eye-strain, dental caries, or nasopharyngeal disease, are frequently only coincidental conditions. Ocular defects are more frequently the cause of other forms of headache.

Indigestion and intestinal autotoxemia are the most important acquired factors in the causation and persistency of the affection. Neurasthenia and hysteria, gout and various lithemic conditions also play an important rôle. The constitutional substratum varies in different individuals. Among the exciting causes of attacks may be mentioned mental overwork and anxiety, excessive fatigue or exhaustion from any cause, constipation, errors in diet, menstruation, and emotional excitement.

Diagnosis.—It is differentiated from other forms of headache by its periodical and paroxysmal character, its usual limitation to one side of the head, and its association with transient visual disturbances and other evanescent sensory symptoms, the absence of evidence of organic intracranial disease, and the good health of the individuals during the intervals between the attacks.

Course and Duration.—Migraine usually begins after the twentieth year, but it has been known to commence as early as the fifth or sixth year of life. The interval between the attacks varies from two weeks to several months, the length of time often being modified by treatment. During these intervening periods, the patient may appear perfectly well. In women the attacks seem to occur more frequently at or about the menstrual period. In the ordinary form it has a tendency to subside spontaneously about the menopause in women, and after the age of fifty years in men. This is not the rule, for it sometimes lasts through a whole lifetime. When the affection has persisted for several years, the attacks being frequent and severe, it usually leads to a general neurasthenic condition. It is thus commonly found in association with neurasthenia and hysteria. The ophthalmic form of migraine usually appears later in

life, occasionally growing progressively worse, and it has been known to be the precursor of serious organic brain disease. Migraine has occasionally been found in conjunction with epilepsy. In such cases, the migraine attacks have at times alternated with the epileptic seizures or epilepsy has followed migraine which had entirely disappeared.

In rare instances, the attack of migraine is complicated by sudden paresis or paralysis of the third nerve on the same side. The ocular paralysis is usually transient and recurs in varying degrees in subsequent attacks of migraine. In many of the reported cases, the patients have eventually made a complete recovery both from the attacks of migraine and from the accompanying third-nerve affection. But the outcome is not always so fortunate, for in some cases the paralysis gradually increases during the intervals and ultimately becomes permanent.

Pathology.—The pathology is still obscure. The prevailing and most plausible theory is that the attacks are due to periodical discharges of nerve force originating in the cerebral cortex or in the sensory centers, involving principally the intracranial branches of the trigeminus and the pneumogastric nerves. According to a recent "mechanical" theory, the attack is produced by an acute transient closure of the foramen of Munro and a consecutive swelling of the brain (Spitzer).

Treatment.—Patients with migraine should lead a regular life free from excesses of any kind. The avoidance of mental overwork, and the systematic practice of some form of outdoor exercise are always necessary. All sources of reflex irritation should be investigated. Refractive errors should be corrected by suitable lenses, and if there is any defect in the eye muscles it should be remedied if practicable. This does not necessarily imply that every patient with migraine must be subjected to operation or the wearing of spectacles as a routine method. The same rule holds good in regard to operation for deviation of the nasal septum. While some of these patients are in fairly good health during the intervals between the attacks, many suffer from various manifestations of toxemia due to gout or rheumatism, such as stiffness and pain in the muscles and joints, vague and fleeting neuralgic pains, etc. The neurasthenic state also requires careful management. Certainly such indications are to be met, and treatment is to be instituted accordingly. Particular attention should be given to the regulation of the action of the bowels and to proper diet. Hydrotherapy is also a valuable adjunct in these cases. The more intelligent patients usually judge from personal experience when the attack is approaching, and in time they also learn to avoid exciting causes. Various drugs have been recommended to abort the attack in its incipiency, or to relieve the pain during the paroxysm, and as a rule they are more effectual the earlier they are administered. Among these may be mentioned: ℞ Caffeine, gr. ij.; phenacetin, gr. x., with or without potassium bromide, gr. xv. ℞ Acetanilid, gr. ij.; caffeine, gr. ij., to be repeated in twenty or thirty minutes if necessary; or ℞ Codeine, gr. ¼; acetanilid, caffeine, āā gr. ij. At times a brisk cathartic, such as two or three ounces of Rubinat water, or a few ounces of a strong infusion of coffee, or a moderate dose of wine, whiskey, or champagne will abort the attack, if taken early. If the paroxysm is very severe the pain will generally be relieved by the hypodermatic injection of morphine, or morphine or codeine may be given by the mouth if nausea and vomiting are absent. Some patients obtain relief from applications, to the head, of hot-water cloths or a hot-water bag, while others prefer the ice bag. This is purely a matter of individual susceptibility. A mustard plaster over the nucha, or over the side of the neck in the course of the pneumogastric nerve, also at times diminishes the pain. The use of arsenous acid and extract of cannabis indica administered for a prolonged period of time, has proved that they are most serviceable drugs. ℞ Ext. cannabis indicæ, gr. ⅙; acid. arsenos., strych. sulph., āā gr. $\frac{1}{50}$; quinin. sulph., gr. ½; extr. taraxaci, q. s. M. ft. pil. No. i. These pills, given after meals for one week—the dose of the various ingredients being gradually increased each week—should be taken regularly for many months or a year.

When the attacks are frequent and severe, the administration of potassium bromide gr. xv., and fluid extract of ergot ♏ xv. t.i.d. proves serviceable during the first few weeks of treatment.

Organic Headache.—Headache is commonly a pronounced symptom in all inflammatory processes which affect the exterior or interior of the skull. It thus occurs in disease of the periosteum, in caries of the petrous portion of the temporal bone, in inflammation in the cavities situated in the skull, as the frontal and sphenoidal sinuses, the orbital cavity and the middle ear, and in diseases of the brain and meninges. Headache as it occurs in the following conditions will be briefly described: 1. Intracranial tumor. 2. Cerebral abscess. 3. Leptomeningitis. 4. Pachymeningitis. 5. Intracranial syphilis. 6. Vascular disease. 7. Encephalitis. 8. Mastoid disease and sinus thrombosis. 9. Disease of the cranial bones. 10. Diseases of the frontal sinus. 11. Caries of the cervical vertebræ. 12. Acromegaly. 13. Spinal-cord disease.

1. *Intracranial Tumor.*—The most persistent and distressing form of headache is that which occurs in patients with intracranial tumor. It is one of the most constant and obtrusive symptoms. In exceptional instances, headache may be absent during the entire course of the disease. But such a condition is very rare, the headache varying in intensity in different cases. Occasionally it may be of a mild character. As a rule it attains great severity, preventing sleep, and at times becoming so unendurable that the patient has been known to commit suicide. Sometimes the pain is paroxysmal, but more frequently it is almost continuous with periods of great exacerbation. The headache is usually diffuse, but it may be limited to the forhead, parietal region, or occiput, changing its location from time to time. The seat of the pain in the cranium does not necessarily imply that the growth is subjacent. When the pain is confined to the frontal region it by no means indicates that the frontal lobes are involved, for such pain often occurs in cerebellar tumor. The presence of persistent occipital pain extending to the neck would lead us to assume that the growth is probably situated in the posterior cranial fossa. If the headache is limited to a circumscribed area it most frequently corresponds with the location of the growth which has also involved the underlying meninges. If it be confined to one side of the head, the probability is that the tumor is on the same side. This is not an invariable rule, however. The pain is aggravated by everything that interferes with the cerebral circulation. It is thus made worse by, psychical excitement, alcohol, coffee, muscular activity coughing, straining at stool, sneezing, etc. Headache can be considered only one of the prominent general symptoms of brain tumor, and in itself it is of no value in localization. The other important general symptoms frequently found in association with the headache are vomiting, double optic neuritis (choked disc), and vertigo. Various symptoms indicating the location of the lesion are usually present. It is universally assumed that the headache is produced by irritation of the numerous branches of the trigeminus supplying the dura. The dura may also be stretched and irritated as a result of intracranial pressure. If this be true, in the former condition the pain would probably be circumscribed, while in the latter we would expect it to be diffused. Clinical facts, however, cannot always be reconciled with this view.

2. *Cerebral Abscess.*—In cerebral abscess headache is the earliest and most constant general symptom, just as it is in brain tumor. It is generally of great severity, but often manifests itself as a persistent dull ache, deeply situated, and referred mainly to the seat of the abscess. The development and growth of the abscess are likely to produce paroxysms of headache of the severest type. During the latent stage the pain may be slight and occur only periodically. The attacks may last for from several hours to severa days. As in brain tumor, the pain is aggravated by everything that causes mechanical congestion or increases the intracranial circulation. The headache may be general, but is more frequently confined to the same side as the abscess. In otitic abscess it may be strictly circumscribed to the temporal region, the pain being first experienced in the ear, and later radiating over the entire head. Abscess in the cerebellum may begin with frontal headache, but is usually accompanied by pain in the occipital region and neck. In cerebral abscess the headache is generally associated with other symptoms of intracranial pressure, as optic neuritis, vomiting, and slowness of the pulse. As the disease advances, there may be general or localized convulsions, weakness of memory, restlessness, irritability, or mental confusion. Fever is generally present, but often disappears for varying periods, only to return higher than before. Frequently the temperature is normal or subnormal. The commonest cause of abscess in the brain is middle-ear disease. In such cases the temporal lobe or cerebellum is most frequently involved.

3. *Inflammation of the Pia or Leptomeningitis.*—This is always due to an infective process. The acute form is often purulent, and of the cerebrospinal type. Extremely severe general headache is a persistent, prominent, and obtrusive symptom. It may precede or follow a chill and rise of temperature. There may be vertigo, vomiting, general hyperesthesia, rigidity of the neck muscles, inequality of the pupils, and, later, mental confusion and coma. In *chronic leptomeningitis* persistent headache is a frequent symptom, but it is not present in every case. Its severity is probably dependent on the extent of the process. It is usually accompanied by signs of intracranial pressure, such as vomiting and optic neuritis. The disease may attack either the convexity or the base of the brain. In the former, the cranial nerves escape, there is more delirium, and there may be unilateral or general convulsions and hemiparesis. In the latter, several or many of the cranial nerves may be involved, and there is more marked rigidity of the postcervical muscles.

4. *Inflammation of the Dura or Pachymeningitis Externa.*—The headache is usually circumscribed, and is often accompanied by nausea or vomiting and slight fever. When only one side of the convexity of the brain is involved the pain is confined to the same side. In severe cases the disease may extend to the pia, and it is then often accompanied by typical Jacksonian epileptic attacks and hemiparesis on the opposite side of the body. It is usually the result of traumatism to the skull, of caries of the petrous portion of the temporal bone, as in mastoid disease, of syphilis, and of ethmoidal caries. *Pachymeningitis interna or hematoma of the dura* is also accompanied by headache and somewhat similar symptoms. This disease occurs most frequently in old people with chronic alcoholism, syphilis, or dementia.

5. *Intracranial Syphilis.*—Headache may antedate all other symptoms of intracranial syphilis, especially syphilitic meningitis, for several months or years. As a rule, it is the earliest and most constant symptom, and often occurs in paroxysms, or there are periodical exacerbations in which it becomes intolerable. Very frequently such exacerbations occur toward evening or at night, and thus prevent sleep. At times the attacks are periodical. At the height of the paroxysm the pain often becomes excruciating, while during the intervals it may diminish to a dull aching sensation or entirely disappear. The headache is rarely circumscribed (unless there is disease of the cranial bones), but is usually distributed over the frontal, temporal, or parietal regions, and eventually over the occiput and neck. Extreme tenderness on pressure upon the skull occurs only when the periosteum or bones are involved at the same time. The pathological process affecting the intracranial structures is that of arteritis, gumma, or gummatous meningitis. It is not uncommon for all three conditions to exist at the same time. The meningitis is frequently of the type of a meningoencephalitis, and may be confined either to the convexity or to the base of the brain. In the former, there are more delirium, and disturbance of consciousness, and localized or general epileptic seizures, sometimes followed by hemiparesis or hemiplegia. In the latter, the cranial nerves at the base often become involved, thus producing facial or ocular paralysis, etc. Chronic syphilitic meningitis is generally local, and occurs chiefly in the neighborhood of a gummatous growth. The main features or general symptoms of cerebral syphilis are similar to those of tumor. Thus, in addition to headache, there are vomiting, double optic neuritis, and various paralyses. Mental hebetude, somnolence, or periods of unconsciousness are often characteristic and almost pathognomonic symptoms that occur in association with the persistent headache of intracranial syphilis. In addition, there often are alterations in character, loss of memory, mental dulness, and absence of the pupillary light reflex. The examination of the cerebrospinal fluid obtained by lumbar puncture (not contaminated by blood) is imperative in doubtful cases. The presence of a positive Wassermann reaction, together with an excess of globulin and lymphocytes renders the diagnosis of cerebrospinal syphilis beyond question. The discovery of a positive Wassermann reaction in the blood serum, however, is insufficient.

6. *Vascular Disease.*—Headache due to arteriosclerosis is essentially the result of circulatory disturbances in the brain and interference with nutrition. (See above in the sections on Cerebral Hyperemia and Anemia.) In syphilitic endarteritis, however, the headache is not due to the arterial changes alone, but to the associated meningitis or gumma. Vascular disease, such as arteritis and sclerotic degeneration, frequently arises in conjunction with chronic renal disease, chronic gout and rheumatism, and old age.

7. *Encephalitis.*—This is an acute inflammatory affection of the brain. It has recently been well described by Oppenheim as "acute primary hemorrhagic encephalitis." The headache is very severe, and generally affects the entire head, or the pain may be greater in the occipital region and neck. It is accompanied by vertigo, nausea and vomiting, apathy and general depression. These symptoms are soon followed by somnolence, which rapidly develops into unconsciousness. Later, there may be monoplegia, hemiplegia, and various other signs indicating involvement of special cerebral centers. Recovery is not infrequent. The disease is rare, and generally affects young people between fifteen and thirty years of age. As it most frequently complicates or follows acute influenza, it has also been termed "influenza encephalitis." It is acute in its onset, beginning like many of the acute infectious fevers.

There is another form of encephalitis known as "acute polioencephalitis superior." After several days of headache, vertigo, and vomiting, mental confusion and delirium take place. At about the same time the eyes become involved in paralysis of ocular muscles, which at times develops into complete ophthalmoplegia. It usually terminates in death in about two weeks. Recovery is rare. This disease was originally described by Wernicke. It is an acute

hemorrhagic encephalitis confined mainly to the gray matter in the floor of the third ventricle and that of the aqueduct of Sylvius. Chronic alcoholism and infection are the usual causes.

8. *Mastoid Disease and Sinus Thrombosis.*—Headache occurring in these conditions is usually on the same side as the lesion. Beginning in the ear the pain radiates over the entire side of the head. When severe, it generally arises in consequence of the extension of the infective process to the dura. As the local and general pyemic infection advances, the headache often diminishes *pari passu* with the obtunding of the sensorium. Furthermore it may be complicated by the presence of a dural, temporal, or cerebellar abscess, and leptomeningitis may ultimately develop with its usual train of symptoms. Mastoid disease and sinus thrombosis are in nearly all cases due to middle-ear disease and caries of the petrous portion of the temporal bone. Sinus thrombosis is also a complication of facial carbuncle and erysipelas of the head.

9. *Disease of the Cranial Bones; Periostitis.*—Bone disease affecting the exterior of the skull is the result of traumatism in the majority of instances. In a large proportion of cases, however, there may be periostitis due to syphilis, *i.e.* periosteal nodes over the cranium. Circumscribed gummata of the skull arise in the most part in the epicranial periosteum. In such cases headache is often constant and, as in all forms of intracranial syphilis, is liable to exacerbations during the night. The bone affected is usually tender and painful to the touch. The headache accompanying cranial periostitis may be mistaken for the form of headache due to muscular rheumatism, or *vice versa.*

10. *Disease of the Frontal Sinus.*—In catarrh or suppuration in the frontal sinus, the headache is confined to the frontal region as a rule, but may become general, with the greatest intensity over the affected sinus. At first the pain is dull and intermittent in character. It may gradually or suddenly become persistent and severe and prevent sleep. Percussion over the sinus usually increases the pain. Swelling and tenderness of the tissues over the region of the affected sinus are commonly present, and ultimately all of the symptoms of local and general infection may develop. The radiographic picture will often confirm the diagnosis.

11. *Caries of the Cervical Vertebræ.*—Occipital headache is commonly present in caries of the upper cervical vertebræ. The pain may extend to the parietal and temporal regions, and is increased by movement and deep pressure over the vertebræ. It is usually accompanied by rigidity of the neck muscles, or the head may be partially fixed in the median line.

12. *Acromegaly.*—The headache may be localized in the occiput or the frontal region, or be confined to one side of the head. It may be continuous or intermittent, and is often persistent and severe, usually being worse in the morning. It is almost always accompanied by ocular symptoms, such as impairment of central vision or bitemporal hemianopsia, which often terminates in optic atrophy and complete blindness. Acromegaly is a rare disease, and was first described by Pierre Marie of Paris, in 1886. Since that time many cases have been observed in this country and elsewhere. The diagnosis of the cause of the headache can be made only by a recognition of the associated pathognomonic physical signs of the disease, *i.e.* enlargement of the hands and feet, enlargement of the cranial and facial bones, hypertrophy of the tongue, and of the muscular and connective tissues of the extremities, slow but progressive weakness, and the visual defects as above described.

The headache may continue for years or persist during the progress of the affection, and is supposed to be due to the enlargement of the hypophysis (pituitary body).

13. *Spinal-cord Disease.*—Headache cannot be considered a symptom of spinal-cord disease. When it is present, it is merely a coincidental element in the general constitutional disturbance, or due to some complication. The characteristic tabetic neuralgic pains occasionally attack the scalp, and are due either to involvement of the spinal or cerebral sensory root of the trigeminus, or to irritation in its peripheral distribution.

General Diagnosis.—The diagnosis of the cause of headache depends entirely upon the patient's history and the presence or absence of certain associated symptoms. This will be readily appreciated after a review of the conditions in which headache occurs, either as a concomitant or as a pathognomonic symptom. The general health of the patient must always be carefully investigated, particularly with regard to the function of the digestive tract and the action of the kidneys. While the seat of the pain is often suggestive, too much stress must not be placed on this indication, for in all forms of headache the pain may vary in its location from time to time. In supraorbital and occipital neuralgia, the pain is more or less paroxysmal and superficial in character, being usually confined to the anatomical distribution of the nerve, and is therefore not a true cephalalgia. Continuous headache lasting many days, with nocturnal exacerbations, should always lead to the suspicion of cerebral syphilis, and the diagnosis may often be confirmed by serological and cytological examination of the blood and cerebrospinal fluid. It is always necessary to decide whether the headache is due to a functional disturbance, or is the result of organic intracranial disease. A safe rule to follow in all cases of persistent headache is to ascertain if any signs of cerebral disease are present, such as muscular spasm; paresis or paralysis affecting the face, extremities, or cranial nerves. A constant general headache which is accompanied by optic neuritis and frequent attacks of vomiting invariably points to intracranial disease. The examination of the pupils should never be omitted. In hyperemic forms of headache the pupils are usually contracted, while in anemia they are found dilated. When the pupils fail to react to light, or are absolutely rigid, the vision being unaffected, it is highly suggestive of cerebral syphilis or some other form of cerebral degeneration. The ophthalmoscope often proves extremely valuable in diagnosis. Although abnormities of the cerebral circulation may exist without evidence of such disturbance in the retina, the discovery of "choked disc" or optic neuritis, or a high degree of hypermetropia or myopia, will often be the means of determining the cause of the headache. The most important use of the ophthalmoscope in cases of headache is to determine the presence or absence of optic neuritis. While its absence does not exclude organic disease, its presence is presumptive evidence of some form of intracranial disease (basal meningitis, increased brain pressure from cerebral tumor, or the vascular degeneration associated with renal disease).

Treatment.—A careful investigation of the entire organism is essential in every case, the most important element in the treatment of patients with headache being the recognition of the cause, as the pain is oftener dependent upon some underlying constitutional condition than upon organic intracranial disease. The discovery and correct interpretation of such facts should be the principal guide in the adoption of therapeutic measures. In the toxemic form of headache, as well as in all other forms, it is absolutely necessary that the intestine be kept free from fecal accumulation, and that the action of the digestive organs be regulated by suitable diet. Headache from constipation is rapidly relieved by a brisk cathartic. All supposedly reflex causes should be rectified, but too much stress must not be laid upon the paramount importance of such disorders, for many patients seem to possess an

inherited or inherent predisposition to develop headache upon the slightest provocation. It is generally desirable and universally advocated that any existing error of refraction or eye-muscle defect be corrected. Even when such conditions are discovered and remedied, relief from the headache does not always follow, for several causes may be operative in the same individual. Therefore, before saddling a patient with spectacles for slight refractive errors, or cutting the eye muscles, or operating upon the nose for deviated septum, or replacing a slightly displaced uterus, or suturing a trifling laceration of the cervix, etc., all other probable causes of the headache should be systematically eliminated. Headache due to cerebral congestion may be relieved by the avoidance of all forms of cerebral stimulants and psychical excitement, regulation of the diet, free purgation by calomel and salines, and the administration of bromide of potassium gr. xv., and fluid extract of ergot ℥ xv., every three or four hours. Severe cases require cupping or blistering over the nucha, and local blood-letting or venesection. It would appear from the experiments of Leonard Hill and others upon dogs that the application of ice-bags to the head as a form of treatment has practically no effect upon the cerebral circulation. Hence the time-honored custom of using the ice-coil and ice-bag in cases of meningitis or cerebral congestion is without any scientific evidence as to its action. Its clinical value, however, is still an open question. When the ice-cap is used, it should always be applied to the shaven scalp. In headache from cerebral anemia, rest in bed with the head low, and special attention to the cause (which is usually general anemia) are of prime importance. The administration of cardiac tonics, and the use of iron and easily assimilated food, generally prove successful when organic visceral disease is absent. In every form of headache we are often forced to resort to the temporary use of local applications of dry or moist cold or heat, or some form of anodyne or counter-irritant. Antipyrin, acetanilid, phenacetin, caffeine with bromide of potassium, etc., or diffusible stimulants such as aromatic spirit of ammonia, tincture of valerianate of ammonia, etc., often prove serviceable as symptomatic remedies, but their selection must be left to the judgment of the physician. When headache accompanies the infectious or malarial fevers, the reduction of the temperature by hydriatric or other appropriate measures, or the use of quinine, usually proves efficacious. Headache due to syphilis (gumma, meningitis, periostitis) is rapidly relieved by neosalvarsan, mercury, and iodide of potassium. In headache due to cerebral tumor, free catharsis from time to time, the avoidance of cerebral stimulation or of causes known to produce interference with the intracranial circulation, the administration of the drugs above mentioned, or morphine if necessary, constitute the essential features in the medical treatment. The operation of either subtemporal or suboccipital decompression, depending whether the tumor producing intracranial pressure is hemispheric or subtentorial, is the best means of relieving the headache and other general symptoms such as vomiting, vertigo, and optic neuritis. The latter, whenever accompanied by signs of interference with either central or peripheral vision, is a most significant symptom portending blindness. Decompression is then imperative. It not only relieves the headache, but, when performed early, it saves the patient from blindness. Hence, in such cases, delay while waiting for the action of remedies such as mercury and potassium iodide is unwarranted. Heretofore, it has been customary, before operating, to institute a thorough course of antisyphilitic treatment in order to give the patient the benefit of any doubt as to the possible gummatous character of the growth. The subsidence of headache and other general symptoms of cerebral tumor during the administration of mercury and the iodides, however, does not necessarily imply that the neoplasm is syphilitic, for the irritative symptoms of sarcomatous and other intracranial pathological processes have been known to undergo retrogression under this plan of treatment. When the tumor is accessible to surgical measures, it should be removed as soon as its location is established.

In headache associated with cerebral abscess, correct localization and immediate surgical operation constitute our only hope. In cases of doubt as to the presence of otitic temporosphenoidal or cerebellar abscess, it is advisable to explore the middle and posterior cranial fossæ as soon as possible (as death may suddenly occur from rupture of the abscess into the ventricles) rather than to endanger the patient's life by prolonged observation for the purpose of making a positive diagnosis. WILLIAM M. LESZYNSKY.

Healing Springs, Alabama.—Healing Springs, Washington County, Alabama.

POST-OFFICE.—Healing Springs. Hotel. Numerous Cottages.

ACCESS.—Via the Alabama, Tennessee and Northern Railroad to Millry, Alabama, and thence one mile to Springs and Hotel. Hacks meet all trains. The Springs can also be reached via Bucatunna, Mississippi, on the Mobile and Ohio Railroad, seventy miles north of Mobile, and fourteen miles east of the Springs. These springs were discovered in 1870, and have since attained considerable prominence as a health resort. The surface of the country about the springs is broken by high ridges and slopes, and covered by the long-leaved yellow pine. The soil is sandy, and the location has an elevation of about 400 feet above tide water. Like all resorts in this latitude, the winters are mild, the temperature seldom dropping below freezing point. The summers are not exceptionally hot, the mercury almost always sinking to 68° or 70° F. at night. During the recent summer the highest temperature observed was 92° F. The springs are eleven in number, but only four are much used. The "Creek" Spring boils up in the center of a small stream and flows about eight gallons per minute. "Mound" Spring, yielding thirteen and a half gallons per minute, issues from a small mound five or six feet higher than the ground around it. "McCarty" Spring, supplying seven gallons per minute, is supposed to contain an acid of some kind and also iron. Its waters are used extensively for chronic diarrhea. "Scholes" Spring contains iron and sulphur. Many varieties of skin affections, chronic renal diseases, disorders of the bladder, alimentary tract, and liver, and diseases of women are said to receive benefit from the waters of the Healing Springs.

The following analyses were made by Eugene A. Smith, Alabama State Geologist:

	Grains per gallon.	
	Creek Spring.	Mound Spring.
Sodium chloride	0.33	0.33
Sodium sulphate	0.05	0.00
Potassium sulphate	0.18	0.20
Magnesium sulphate	0.45	0.55
Magnesium bicarbonate	0.27	0.00
Calcium bicarbonate	2.15	1.79
Iron oxide (ferric)	0.28	0.28
Silica	1.58	1.68
Calcium sulphate		0.18
	5.29	5.91

EMMA E. WALKER.

Healing Springs, Va.—See *Hot Springs, Va.*

Health, State Boards of.—To provide for the safety of the people is a fundamental function of government; it can make no higher law according to the old Latin maxim. Every well-organized government recognizes this obligation and formulates statutory regulations to protect the public or in their absence exercises police power under the common law; and civilized communities accept as fitting that when the welfare of society requires it individual right to liberty and property must give way. Safeguarding the public health comes under this justifiable police power of orderly government, and in later time laws and executive activities to this end have come into existence.

Under the policy of government in the United States the authority for this is vested in the separate States rather than in the Federal Government. It has been assumed by them directly during the last quarter of the nineteenth century, prior to which time health work was for the most part carried out, if at all, by their lesser political divisions.

The Federal Government at Washington has not assumed, unless perhaps in exceptional cases, to control officially the health service of the States. It has, however, done much public health work. The United States Public Health Service is an organization of Federal authority under the direction of the Treasury Department, which cooperates with the State and local health departments and does general work of importance. It publishes weekly reports of health throughout the country and the world, with other valuable material relating to the public health; it has supervisory authority to some degree over quarantine; it has the oversight of institutions whose products are of general concern, such as establishments for the production of vaccine virus; it furnishes expert assistance in cases of extraordinary need, and has made elaborate investigations of endemics such as the hookworm disease; its hygienic laboratory does work in research and special investigation; in its various bureaus it carries on extensive work. It issues instructive bulletins on special subjects; acknowledgment is made in preparing this article to one of its recent publications, a comprehensive bulletin on the "Organization, Powers and Duties of Health Authorities," prepared by Dr. J. W. Kerr, Assistant Surgeon-General. The Department of Agriculture has supervision over foods and drugs; the Pure Food law and its execution is a Federal activity; the Department of Commerce, in the Bureau of the Census, has to do with vital statistics. Doubtless it would be of very considerable advantage if all this Federal public health work were coordinated under a single head.

Organized establishments as a part of the government in the States for protecting the public health belong to recent time. Prior to the nineteenth century, in absence of statutory regulations, official action was taken only sporadically as local conditions arose which compelled it; outbreaks of smallpox, yellow fever, or cholera called for measures to control them by the localities in which they occurred, and local authorities acted under the common law and their own police authority during the continuance of the pestilence. The larger cities were the first to realize the need of permanent establishments to care for health, as the exigencies of growth and seaport exposure made this apparent, and about the beginning of the last century boards of health began to be formed in the cities. Baltimore, Philadelphia, New York, and Boston about this time created boards of health, and in succeeding years like action was taken by all important cities, forming them under the provisions of their charters, or by municipal ordinance or under the authority of special State law. In 1797 Massachusetts enacted a State law which provided for the establishment of town boards of health and gave them authority to make such regulations as each might judge necessary for the public health. This was the first step taken in this country toward uniform sanitary legislation and served as a model for similar action in other States. Provision for local boards of health was made by most of the States, although by few of them until fifty years later. Not townships alone, but cities, villages or counties were thus provided for; how generally, save by more populous communities, this authorization was acted on and how effectively in the absence of central supervisory control cannot be very well stated. However it is evident that there was a good deal of local health work done before State boards of health came into existence, even in the smaller communities throughout the country.

As Massachusetts led in providing State legislation for local boards of health, so also she did in establishing State boards of health, as the term is now understood. In 1849 the legislature authorized the governor to appoint a commission to make a sanitary survey of the State. The thorough and comprehensive document prepared as the report of this commission presented a plan of organization for a general or State board of health which was so complete that it was closely followed when the State board was brought into existence twenty years later, and indeed furnished a model for the guidance of many other States subsequently. The coordination of health work by State organizations does not appear to have been felt as necessary before this. In the colonies and the sparsely settled States there was little need for such supervision, and the subject of public hygiene had not enlarged sufficiently to emphasize its importance. Louisiana had as early as 1865 formed what was called a State board of health, but it could hardly be so regarded since it was created only for the purpose of maintaining a quarantine to protect the city of New Orleans. It is fair to say that the one set up by Massachusetts, in 1869, is entitled to the primacy. Other States soon followed this lead and largely this guidance, so that in 1880, when action of this sort was taken by New York State, boards of health were created in twenty States, and by 1909 every one of the forty-eight States had such an establishment.

State boards of health have been created in the following years:

1869 Massachusetts.
1870 California.
1872 Minnesota, Virginia.
1873 Michigan.
1874 Maryland.
1875 Alabama.
1876 Wisconsin.
1877 Illinois, Mississippi, North Carolina, Tennessee, Connecticut, Kentucky.
1878 Rhode Island, South Carolina.
1879 Delaware.
1880 Iowa, New York, Arkansas, Indiana.
1881 New Hampshire, West Virginia.
1883 Missouri, Kansas, Maine.
1885 Pennsylvania.
1886 Ohio, Vermont.
1889 Florida, North Dakota.
1890 Oklahoma.
1891 Nebraska, Washington.
1893 Colorado, Nevada.
1895 South Dakota.
1898 Utah, Louisiana.
1901 Montana, Wyoming.
1903 Arizona, Georgia, Oregon, New Mexico.
1907 Idaho.
1909 Texas.

In most of the States the central health authority is vested in a board or department of health, and designated as such officially. Appointment of the members, of whom they are variously composed, is generally made by the governor with the consent of the senate; exceptions to this are few. Alabama constitutes "The Medical Association of the State of Alabama" the State Board of Health, under which

title the law proceeds to outline its duties and jurisdiction. In Arizona the governor, attorney-general and a superintendent of health appointed by the governor and senate comprise the board. Nebraska makes the governor, attorney-general and superintendent of public instruction the board of health. New Hampshire's board is made up of the governor attorney-general, three physicians and a civil engineer; North Dakota, the attorney-general, a superintendent of public health, and one other, both appointed by the governor. In South Carolina the State Medical Association and the attorney-general compose the board and elect an advisory committee of seven members. In Tennessee the board of health consists of three physicians and the commissioner of agriculture. The board must be made up exclusively of physicians in twelve States. In thirty-one States there must be physicians on the board. In ten States a majority of the board must be physicians. In a few States it is required that various recognized schools of medicine must be represented. Ex-officio members, including the attorney-general, the State engineer, State veterinarian, State commissioner of agriculture, the governor, the superintendent of public instruction, are required on the board in nine States, and in Maryland the commissioner of Health of Baltimore is a member. In some States the law requires the membership of an attorney, a civil engineer, or a veterinarian. In the latter case, the board has control of domestic animal diseases. No designation is made as to the personnel of the board in ten States, although the qualifications of those appointed sometimes are specified, as that they shall be versed in matters relating to the public health; and certain obvious qualifications are required generally as to medical appointees.

Instead of a board of health, in three States there is a commissioner of health, one man charged with the duties of a board. In New York the central health authority came into existence in 1880 as a board of health, which in 1901 was replaced by a Commissioner on whom its authority devolved. In 1913 his term of office was made six years, and an advisory council of six members was made, without executive function other than to establish sanitary regulations having the force of law and to prescribe the qualifications of subordinate officials and of local health officers; at the same time it was enacted that the State be divided into twenty sanitary districts with a head to look after the conditions of health in each.

Oklahoma placed its health authority in the hands of one commissioner of health, appointed by the governor for a term of four years. In Pennsylvania the department of health consists of a commissioner of health and an advisory board of six members, having until recent time been constituted as a board of health. Texas on the other hand having had one commissioner now has established a board of health. In the District of Columbia there is no board, a health officer discharging the functions thereof in the Federal District.

The term of office of members of boards of health is, with few exceptions, from four to seven years. Their compensation beyond reimbursement for expenses is seldom other than a per diem allowance, and in not a few States none is provided for.

An executive officer, entitled the secretary or State health officer, is commonly provided for by the law. He is elected by the board of health, or in a few States appointed by the governor. His term of office is fixed by law save in a few States; his salary in less than half the States exceeds $3,000; his qualifications are more or less exacting, generally that he must be a physician, having had certain years of experience in professional work and familiarity with what constitutes sanitary science. His duties are to enforce the laws of the State for the protection of the public health and the regulations of the board of health, and to perform specific duties assigned by it, being subordinate to the board although generally its only executive functionary.

There is provision in law for the employment of other officers to carry on the work. The executive officer is sometimes given an assistant or deputy; a sanitary or civil engineer, a lawyer, bacteriologist, chemist, and others expert in various directions are provided for. In a few instances the State is divided into sanitary districts with a health officer to look after its narrower limits under the direction of the board of health and its executive officer.

To carry on the public health work States have appropriated various relative amounts, to some extent dependent on the extent and character of duties placed upon the board of health. In some this includes antitoxin establishments and the distribution of their products, carrying on of tuberculosis sanatoria and dispensaries (as in Pennsylvania), enforcement of pure food laws and inspection of cold storage plants, while most maintain hygienic laboratories, engineering work, collection of vital statistics. Assistant Surgeon General Kerr gives in the Bulletin heretofore referred to the following appropriations of the States for the use of boards of health, with the statement, which is obvious, that it is difficult to estimate the exact amount intended for one year. In New York the City of New York is outside the jurisdiction of the State Department of Health, and this may be true of other metropolitan States.

State.	Population 1910.	Amount for fiscal year. 1912	1913.
Pennsylvania	7,665,111	$1,853,740	
Massachusetts	3,366,416	174,900	
New York	9,113,614	166,437	188,670
New Jersey	2,537,167	114,500	125,425
Illinois	5,638,591	118,500	118,500
Minnesota	2,075,708	62,500	67,000
California	2,377,549	60,766	61,400
Indiana	2,700,876	59,500	59,500
Ohio	4,767,121	50,482	
Louisiana	1,656,388	40,000	40,000
Virginia	2,061,612	35,000	35,000
Maryland	1,295,346	36,500	36,500
Montana	376,053	34,900	33,900
Oklahoma	1,657,155	30,700	30,700
Georgia	2,609,121	30,500	30,500
Kansas	1,690,949	43,400	28,400
Kentucky	2,289,905	30,000	
Colorado	799,024	26,450	
Michigan	2,810,173	25,500	25,500
Alabama	2,138,093	25,000	25,000
Missouri	3,293,355	23,650	23,650
Vermont	355,956	21,500	21,500
Wisconsin	2,333,860	20,600	20,600
Connecticut	1,114,756	20,000	20,000
Mississippi	1,797,114	25,000	19,000
North Carolina	2,206,287	18,000	18,00.
Rhode Island	542,610	15,000	17,700
Idaho	325,594	16,050	16,050
Maine	742,371	15,000	15,000
Oregon	672,765	15,000	15,000
Tennessee	2,184,789	14,700	14,700
Iowa	2,224,771	8,600	8,600
Utah	373,351	13,375	
Washington	1,141,990	13,500	13,500
New Hampshire	430,572	11,750	13,000
Nevada	81,875	10,000	
Nebraska	1,192,214	9,240	9,24
Delaware	202,322	6,000	6,000
Arizona	204,354	4,500	
North Dakota	577,056	2,700	2,700
South Dakota	583,888	2,000	2,000
Wyoming	145,965	1,500	1,50
West Virginia	1,221,119		1,500
Florida	752,619	A property tax of 8½ mills annually	

The powers and duties of State boards of health are stated more or less exactly in the laws which create them. Broadly stated, they are given authority to have supervision of all matters relating to the preservation of the life and health of the people; to make and enforce all needful rules to prevent disease of human beings and in some cases of animals, and to carry into effect the health laws of the State. The section of the law relating to powers and duties is in many of them so similar in phraseology as if one model had been followed, that one of them may be given as illustrative, taking that of New Jersey:

"The said State board shall take cognizance of all matters affecting health and life among the citizens of this State, shall make sanitary investigations and inquires in respect of the people, the causes of diseases, and especially of epidemics and the sources of mortality, and the effects of localities, employment, conditions, and circumstances on the public health; they shall make investigations and inquiries into the sanitary condition of any State, county, city, or township almshouse, asylum, prison, penitentiary, jail, reform school, schoolhouse, or other public building, and of tenements, manufactories, and workshops; the said State board shall also constitute a State Bureau of Vital Statistics, who shall, as such board, cause to be made such tabular classification and such index and transcription of the vital facts shown by the certificates of marriages, births, and deaths now by law returned to the Secretary of State as may be useful to the said board or to the officers thereof in preparing for diffusion among the people of the State such facts as may bear upon public health."

The State board is given authority over local boards of health, to supervise the rules and regulations they may make, to direct them in the execution of the same and of the laws of the State, and while the detail of much of the executive work is placed upon the local boards the State board may if deemed necessary assume these duties or enforce action by them. The tendency of more recent time is to enlarge the powers of the State at the expense of the local board and specific executive work is placed directly on it.

In the New England and Middle States and those west which have sprung from them in their early settlement carrying their methods of life and government, the town has been the local unit in compliance with the policy habitual to them. The county has been more often for like reason the basis of local authority in the Southern States and those west of them.

One of the general functions of State boards is to make sanitary investigations of the causes of disease, especially of cummunicable diseases, and the means of preventing them. This investigative function is given wide scope and includes all sources of mortality and the effects of locality, employments, conditions, and circumstances on the public health. In not a few the diseases of domestic animals are included; in New York this along with the care of milk and some other foods is placed on the Department of Agriculture, tenements and factories are under the Department of Labor, and school hygiene is a charge of the Department of Education. It would perhaps simplify and lessen the cost for all States if every source of ill-health were placed under one responsible controlling authority.

In some States wherein specific endemics exist, such as hookworm disease or pellagra, there is the direct duty placed on the board to investigate them. Tuberculosis has within recent years been made a special administrative subject of care and in some, such as Pennsylvania, the maintenance of sanatoria is given. Laboratory work for the investigation of disease, material for diagnosis of water supplies and foods, as well as the making and giving of antitoxins, are a large part of this function of the central health authority. It is very evident that collective investigation, clinical, local, occupational, the wide field for which lies open to State boards of health, may shape into valuable contribution to sanitary knowledge.

Vital statistics, the collection, record, classifying of records of births, deaths, and marriages, are provided for by the law for almost all State boards of health. The forms for this are prescribed by them and local registrars enforce their collection and return them for record and filing to the State board. The establishing of this work is of slow growth and its perfection, on which trustworthy statistics can be based, is variable. The Federal Census Bureau does a great deal toward securing complete returns. The State commissioner of health in New York has authority to take charge of this work in any defective municipality.

Communicable diseases and their control from earliest time were the cause of governmental establishments to protect the public health, and in every health law this is the first duty laid on the State boards, being the primary cause for its existence in the mind of the legislator. To establish quarantine and isolate persons having a communicable disease is made an emphatic function in many of the State laws. The board is authorized to designate the diseases which are to be so regarded and to make regulations binding on local boards for their control. Morbidity reports of the same to health officers are required from physicians and others of all cases, and the same must be reported to the State board; special bureaus are maintained by the board for this purpose. When epidemics prevail the State board furnishes officers to advise as to diagnosis and management and if necessary may take control. Thus in the case of smallpox it may take measures to secure vaccination, which is of far more value than quarantine to control it; in poliomyelitis, cerebrospinal meningitis, pellagra, or hookworm disease expert inspectors available from the central authority may help the locality affected and investigate the characteristics of the endemic. The State laboratory aids in the diagnosis by examination of sputum, discharges from the mucous surfaces, or blood, and serums, etc., for treatment are supplied from antitoxin establishments; in New York and several other States prophylactic outfits for ophthalmia neonatorum prevention are given out to all physicians. Animal diseases are included as under the charge of the health department in a few States only, save as they may affect the health of human beings; antirabic treatment is supplied by some, and protection against diseases of the lower animals in general is authorized by law in others. In New York this class of work is given to the State Department of Agriculture.

Tuberculosis has been made a special subject in recent years for the work of State boards, in some going so far as to provide under them for sanatorium treatment. The revision of the health law of 1913 for New York makes elaborate provision for this and a special division is established with a director for this exclusive work. Cancer investigation is carried on by New York, which has an institute for this purpose.

Water supplies are under the general oversight of all State boards. They provide for the analysis of the water and may make rules for the sanitation of the water shed, and plans for new supplies must be submitted for approval. The general oversight of all inland waters used as sources of supply is specified by some laws, and a large amount of work is done in this by the civil engineering divisions of State boards. Sewage disposal and plans for sewerage systems are under the supervision of State boards, and the protection of streams from pollution. In some states there is provision for the control of garbage disposal.

Railroads are specially made by the law of some States subject to certain control; the movement of trains, also of steamboats and electric cars, in case of epidemics is expressly controllable, aside from the general authority given to health boards; the sanitation of cars and depots is placed under their direction. Summer resorts, public buildings, hotels, factories are subject by law in not a few States to inspection and to enacted regulations. Schools are under general or certain specific supervision of State boards of health,

such as testing the eyesight and hearing of school children, the lighting, heating and ventilation, the recommendation of text-books on hygiene, disinfection and control in times of epidemics, are in many under the State board, while in others this work is largely under other departments of government.

Disposal of the dead and in some the practice of embalming are subject to rules formulated by State boards. The control of cemeteries and burial are regulated and the latter is used further to secure the report of deaths; transportation of the dead is regulated by all boards.

Public health nurses are provided for in New York, to serve under the health officer, in schools, tuberculosis control, visitation of the sick and instruction of households.

The practice of medicine is under the authority of the board of health to some degree in a number of States. In ten it has direction of examination and license; it appoints the examining board in Connecticut and in Pennsylvania the commissioner of health is a member of the medical council of examiners. In New York this work is under the State Department of Education and the Department of Health has nothing to do with it, which is likewise the case in a majority of the States.

Midwives are subject to examination and license through the State board of health in but few States. Authority for this is provided for in the majority of states by special boards. The same is true of nurses, who in but two or three States only are under the examination and license of the board of health or must pursue a course precedent there to approved by it.

Laboratories for research and diagnosis are provided for by practically all State boards of health. Some have one central hygienic laboratory, others have several branches in various parts of the State. The law often specially provides for a bacteriologist and chemist. In some the examination of food, drugs, illuminating oils, is done under the law; water analysis is usual; in one or two the assay of liquors is required. Laboratory diagnosis is the work of all and a most important part of their duties.

Establishments for making vaccines and serums are sustained by some State boards, while others supply these from other sources. Antirabic treatment is authorized by Alabama, Georgia, Indiana, Maryland, Minnesota, New York, and Wisconsin free of cost by the State board; in other States the local boards are given authority to supply it. The United States Public Health Service gives the treatment in the District of Columbia and supplies antirabic virus to State boards on request. Diphtheria antitoxin is distributed to indigent persons, and to all in emergency, in one-half of the States through the State board, and appropriations are made for it by the legislatures. Tetanus antitoxin is supplied by the New York, Connecticut, Kansas, Rhode Island and possibly other laboratories, or provision is made for the free treatment of infected persons. General authority for the distribution of all serums is given—typhoid, tubercle, meningococcic—and control of the quality and sale of the same is given to the boards. Vaccination is in most States under the administration of practically all State boards, and vaccine virus may be supplied by some; Massachusetts maintains a vaccine establishment and supplies the virus free. A law is in force in New York and many other States requiring the vaccination of school children. It would be a wise provision if vaccine virus were altogether made by national or State establishments and supplied free of cost, so as to obviate scruples of the people as to its quality and more to ensure its universal use, along with which would necessarily go the education of the people, whose prejudice or indifference is a chief obstacle.

Besides the bacteriologist and chemist there is explicit or implied authority for the employment of experts in other work and a large function of State boards is to furnish trained officers in work requiring it. Epidemics of common or unusual diseases are investigated by them and help given to local health officers in diagnosis and management. A large work is done by the sanitary engineering division of the New York Department in water supplies, pollution of streams, sewage disposal, swamps, summer resorts, public buildings, offensive trades, nuisances, and typhoid fever; and the same is done to some extent of all state boards. Under the cold storage law the State Commissioner of Health inspects plants and provides for their proper sanitation. State boards make model regulations for adoption by local boards of health.

Lunacy is not generally in charge of health boards. In New Hampshire the State board acts as the commission in lunacy. In New York the local health officer is charged with certain duties toward the indigent insane.

Diseases of domestic animals are included under the jurisdiction of a number of State boards of health, especially in the Western States. A State veterinarian is therefore sometimes made ex-officio a member. In other States this work is under other authority, as in New York, where the department of agriculture is charged with this duty.

The educational work of some State boards is of recent years one of most importance. Provision is made for that of the local health officers and members of boards by an annual conference; in Indiana, Kentucky, Maryland, New Hampshire, New Jersey, New York, Ohio, Texas, Utah, Vermont, Wisconsin, and by New York law attendance by them is required, the local municipality paying the costs of the health officer thereof. Provision has also been made for laboratory courses of instruction for health officers and their attendance encouraged. Not less valuable is the education of the people, and arousing their interest; indifference and ignorance of the masses is a great obstacle to enforcement of sanitary requirements, for with it the law is a dead letter. There is in all health board laws provision for the dissemination of information among the people by special circulars, periodical bulletins, and manuals, and literature of this sort is spread abroad. Local campaigns are conducted for educating the people in the nature of preventable disease and on a great variety of hygienic subjects. Lecturers are sent out to meet all sorts of gatherings, where opportunity offers to reach the people from the platform, and the New York Department has printed lectures with lantern slides which can be presented by anyone before village health organizations in schools and churches. Assemblages, such as State fairs, are utilized for exhibits, and short illustrated lectures and even the phonograph catch the public ear. In the same way demonstrations have been given in the campaign against tuberculosis. Some States have sent health trains abroad; loan libraries are distributed where local interest is awakened. A great deal of ingenuity has been displayed in the preparation of material so as readily to reach the people and fix attention on every sanitary subject.

To carry on their work boards have been given extraordinary powers. They are given control over the enforcement of the laws relating to the public health, and of the regulations which they may make. The power of quarantine with all that it implies is specially mentioned in most enacting laws. Their officers are authorized to enter premises in pursuit of their duties without hindrance. By the recent law in New York State these officers are exempted from being sued or held to liability for any act done with ordinary discretion and in good faith in pursuit of duty. Police officers and sheriffs are often specially required to render aid in the enforcement of health laws and board regulations.

To make regulations which have to some degree the force of law is specifically given to boards of health,

in a few States subject to approval from the attorney general. The legal status of these regulations has often been contested in the courts, and the rulings have been variable. It is held that being created by the statute it has only such power to make regulations as are conferred by statute; generally the power given is capable of very wide interpretation. It is generally held that while the authority vested in them is a reasonable exercise of the police power, their orders must stand the test of reasonableness; that while arbitrary power to deprive persons of liberty and property without due process of law is not constitutionally conferred, to thus interfere with personal rights is limited by public necessity and reasonably required for the protection of the public health. When subjected to judicial review the disposition of the courts is to interpret fairly such regulations and public health laws and hold them as constitutional when established by custom and reason. Judge Vann of the New York Court of Appeals thus gives opinion in an antivaccination suit, after referring to some of the claims brought forward against vaccination and affirming the constitutionality of the law requiring the vaccination of school children:

"The common belief, however, is that vaccination has a decided tendency to prevent the spread of this fearful disease, smallpox, and to render it less dangerous to those who contract it. While not accepted by all it is accepted by the mass of the people as well as by most members of the medical profession. It has been general in our own State and in most civilized nations for generations. It is generally accepted in theory and generally applied in practice both by the voluntary action of the people and in obedience to the command of law. Nearly every State in the Union has statutes to encourage or directly or indirectly to require vaccination, and this is true of most nations of the world. It is compulsory in but few States and cities in this country, but it is countenanced or promoted in substantially all, and statutes requiring children to be vaccinated in order to attend the public schools have generally been sustained by the courts."

He further asserts that a common belief like a common knowledge is to be acted on by the legislatures without proof, and while there is scarcely any belief that is accepted by every one, what the people believe is for the common welfare must be accepted as for the common welfare.

A large number of court decisions on health matters are given by Asst. Surgeon General Kerr in the Bulletin heretofore referred to. This legislative function is in various degrees and details conferred by legislatures on their created boards of health. The tendency is to enact these regulations into law rather than to leave them to the formulation and adoption by boards of health. In New York a large number of specific duties have in later years been placed on the boards of health for execution. In the generally amending act of 1913 the duties of the commissioner of health are more fully defined; a public health council advising to him and with specific duties is formed; a sanitary code and the provisions thereof is provided for along with its enforcement; divisions, nine in number, are specifically formed to be under the direction each of a director, viz., of administration, of sanitary engineering, of laboratories and research, of communicable diseases, of vital statistics, of publicity and education, of child hygiene, of public health nursing, of tuberculosis; sanitary districts, each with a sanitary supervisor, twenty or more in number, to include all but cities of the first class (Buffalo and New York) are formed, with twelve enumerated lines of duty; public health nurses are provided for, both those appointed by the state commissioner and others by local health officers, as appropriation is made for them; laboratories and bacteriologists are authorized for the state department to do work at the expense of the state, hospitals for contagious diseases, and powers concerning village sewers; the powers and duties of local health officers are elaborated in detail, and existing regulations are made toward the management of tuberculosis.

State boards of health are given certain judicial powers as part of their executive functions. They or their executive officer may summon witnesses and compel their attendance, may administer oath and issue warrants for arrest in some states. They may fix penalties for violation of health ordinances and may give hearing thereon and impose them in their judicial capacity.

It is a comparatively short time since State boards of health came into being, most of them during the last three decades of the nineteenth century, yet within that time there has been great advance in sanitary knowledge, which they have utilized and to some degree contributed. Most of the specific germs of disease have been discovered since then; likewise the specific antitoxins. These executive organizations have done much of what has been done to make them available. There has been a consequent saving in health and life. Diphtheria is a conspicuous illustration; in 1887 it caused in the state of New York 6,500 deaths among 5,500,000 people; twenty-five years later, in 1912, there were 1,625 deaths among 9,500,000 people. Typhoid fever in that decade caused 1,600 deaths a year, in the last decade 1,400; malarial diseases 580 then, 90 now; smallpox 100 then, 10 now. These are some of the fair results of organized health work.

An encouraging feature of the general survey just made is the rapid advancement to be noted in health work during the last ten years. The chief causes of this may be stated as, first, the increasing and decided advance of sanitation as a distinct and important part of scientific work and, second, the vigorous and successful efforts made to educate and inform the public concerning the great and vital importance of public health work.

But in spite of the advances made, and gratifying as the record really is, it is painfully apparent that much time, money, and labor have been either wholly or partially wasted by reason of lack of cooperation and coordination.

The advance has been haphazard rather than orderly and systematic. Each State has gone its own way, regardless in the majority of instances of what has been done in other States, or in other countries. The best work done in general sanitation has not been carefully or intelligently studied and the benefits that might have derived from the wider experience of others has been lost. It may be added that this is in some measure, at least, due to the fact that there still exists a serious lack of trained and experienced health workers.

In many of the States there is at present no coherent and well-conceived plan of cooperation along the lines of health work. In many, responsibilities are so divided as to discourage efficient effort. In others, meagre appropriations render advance slow.

While the official machinery for health work varies greatly in the different States, it would seem to be fairly well demonstrated that a department of health with a single trained and efficient head is of much greater value than the old and time-honored health board.

The health board, council, or committee is usually of political origin, generally lacking in competent and trained intelligence, and almost universally barren of beneficial results. It is an outworn and discredited device of place hunters, dividing the responsibility, confusing policies, preventing prompt action, and retarding progress. It would seem that the things most now to be desired are:

1. The establishment of a National Health Department with power (*A*) to coordinate the work of the State Departments of Health by advice and instruction; (*B*) to conduct interstate investigations, as pollution of water supplies, etc.; (*C*) to aid in studies and investigations of serious epidemics; (*D*) to furnish trained health workers for special work when needed

by the States; (*E*) to be a kind of clearing house of health for all the departments of health in the United States.

2. The general abolition of boards of health and the substitution of single-headed departments of health.

3. A thorough study of methods and modes of procedure and a beginning made in an attempt to secure some uniformity of health laws.

4. A still greater effort to educate the public to a proper appreciation of the value and paramount importance of health work.

5. The removal of all State health departments from the blight of political domination. No trained efficient health officer should ever be removed for political reasons. EUGENE H. PORTER.

Health Resorts.—See *Climatotherapy*.

Hearing.—Audition or hearing is the result of processes by which certain vibrations of physical media are taken up by a peripheral sense organ, the ear, and transformed into nerve stimuli which excite in consciousness sensations of a peculiar kind. These sensations we know as *sound*. They are a function of a certain part of the cerebral cortex, the temporosphenoidal lobes. Unfortunately, it is also the rule to designate by the name of "sound" those physical vibrations which are the objective cause of sound sensation but which have nothing in common with it.

This article will be chiefly limited to the treatment of objective or physical sound and the manner in which it affects the mechanism of the ear in giving rise to impulses in the auditory nerves.

Physical sound, as contrasted with sound sensation, is due to vibrations of particles of solid, liquid, or gaseous media. In its vibration a particle may move back and forth in a straight line, as in the transmission of an air wave or in the propagation of a tremor longitudinally along a rod of metal; or it may describe a more or less elliptical or circular path as in a wave of water, and transverse to the direction of wave movement. When a particle is forced from its position of equilibrium, the force with which it tends to resume that position is a measure of the elasticity of the substance of which it forms a part. Elasticity is the property by virtue of which vibrations are propagated.

Transverse and Longitudinal Vibrations. Waves of Sound.—The vibration of particles gives rise to waves having definite form, length, and rate of progress. The waves most familiar to us are those seen on the surface of water formed by an up-and-down motion of the particles in an elliptical curve. The vibration is *transverse* to the direction and length of the wave, and the amplitude or depth of the wave and that of the vibration correspond. The wave length is the distance measured from crest to crest or hollow to hollow; it has no necessary relation to the amplitude of vibration. A stretched string or a tuning fork also executes transverse vibrations, when plucked or rubbed in the usual way. But if a stretched string or a rigid rod be scratched at one end the particles there will be set in oscillation back and forth (longitudinal vibration), and this vibration will be transmitted as a wave along the string or rod and may be heard as sound at the further end, but will make no visible movement. It is important to consider how these longitudinal waves are formed. The particles which are struck or scratched at the end of the string or rod are forced against those immediately adjoining, these in turn crowd upon the particles in front; the energy of the first displacement measures the degree of crowding or condensation thus produced. The particles unnaturally strained together spring away from one another by virtue of their elasticity, and their energy of movement carries them beyond their position of rest, making the number of particles at the previous point of condensation less numerous than normal, thus producing a condition of *rarefaction* as a result of the oscillation. The forward vibration of the particles is thus transmitted as a phase of *condensation* to successive layers of the substance traversed, each condensation being succeeded by a complementary *rarefaction*. The two phases of condensation and rarefaction make up the wave of sound. The length of the wave is the distance measured between two points of extreme condensation or rarefaction. This wave length has no necessary connection with the length of the path described by the individual particles whose motion gives rise to the sound wave.

Aërial vibrations resemble the longitudinal vibrations of solids and liquids in that the sound waves move in the same direction as the particles whose movement produces the waves. The amplitude of movement of the individual particles is very much less than the wave length produced by that movement. In the mobile air the path described by the particle is relatively great, but in a rod of wood or metal or under water, the excursion of each particle in its vibration is infinitesimal in its relation to the wave length or distance between successive condensations or rarefactions. The amplitude of movement of the vibrating particle is a measure of the energy which has been imparted to it, and it has extraordinary physiological

FIG. 3004.—Illustrating Passage of an Air Wave. The balls, E, C, B, etc., represent air particles and the springs the elastic force restoring them to position. (After Tyndall on "Sound.")

significance, for upon it depends the *loudness* of sound. In exact language, the intensity of sound sensation is proportional to the square of the amplitude of the air vibrations which cause it. Tyndall in his work on sound illustrates by a diagram the method by which a "sound pulse" is transmitted (see Fig. 3004). The apparatus consists of a series of wooden balls separated from one another by spiral springs (the balls represent air particles and the springs the elastic force restraining their displacement). On striking the knob A, a rod attached to it impinges upon the first ball B, which transmits its motion to C, thence it passes to E, and so on throughout the entire series. The arrival at D is announced by the shock of the terminal ball against the wood, or, if we wish, by the ringing of a bell. Here the elasticity of the air is represented by that of the springs. The "pulse" may be reduced to such a degree of slowness that it can be followed by the eye.

Vibrations occurring in any medium may be transmitted by direct contact to another medium. Thus, when the bell of a stethoscope is applied to the chest, the vibrations of the chest wall are transmitted to the ear either by the air columns of the instrument or by its solid structure or by both. Vibrations of the bones of the skull are transmitted directly to the tympanic membrane and probably also to the lymph of the labyrinth.

The Production of Tones.—When the pendulum of a clock swings to and fro it might be supposed that a sound would be produced by each excursion of the rod, and this would be the case were not the air so mobile that its particles instantly retreat from the front to the back of the slowly moving pendulum, so that no sensible condensation, which is necessary to the production of a sonorous wave, occurs. That is to say, a certain suddenness of impulse is necessary to start an air wave. Such an impulse is developed when a mixture of oxygen and hydrogen is ignited by an electric spark. The heat generated by the union of the gases causes a sudden expansion which starts a sonorous wave which comes to the ear as a sharp report.

Simple Pendular Vibrations.—Suppose our pendulum to increase its rate of movement gradually; when it swings so fast as to accomplish one complete to-and-

fro movement in about the one-sixteenth of a second a continuous sound of very low pitch should be expected.

In practice it is customary experimentally to produce sounds by the transverse vibrations of tuning forks set upon resonance boxes (see below). The effect of such vibration upon the air is illustrated in Fig. 3005, in which the dark spaces, *a*, *b*, *c*, *d*, represent the phases of condensation, and the light spaces, *a'*, *b'*, *c'*, *d'*, the phases of rarefaction of the air waves. The wave length is the distance measured from *a* to *b* from *b'* to *c'*.

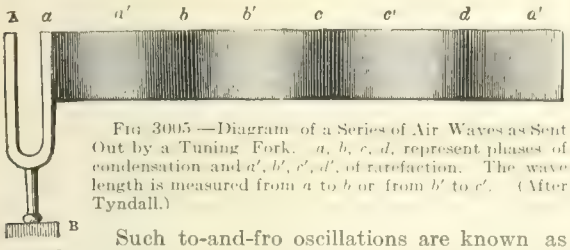

FIG. 3005.—Diagram of a Series of Air Waves as Sent Out by a Tuning Fork. *a*, *b*, *c*, *d*, represent phases of condensation and *a'*, *b'*, *c'*, *d'*, of rarefaction. The wave length is measured from *a* to *b* or from *b'* to *c'*. (After Tyndall.)

Such to-and-fro oscillations are known as *simple pendular vibrations*. They make no audible sound until they attain the rate of sixteen to twenty-four per second, according to the perceptive power of the hearer.

The Pitch and Loudness of Tone.—Instead of using the tuning fork as a source of sound the following familiar device would serve: Take a circular disc, A–B in Fig. 3006, of cardboard or metal about twelve inches in diameter, and let it be perforated at equal intervals along a circle near its circumference. The disc is fastened at its center to the axis of a wheel capable of rapid rotation. A bent tube, *m*, communicating with a bellows giving a continuous blast of air, is brought with its orifice over the circle of holes. When the disc is rotated and air is forced through the tube *m*, a puff of air passes through the disc when one of the holes coincides with the open end of the tube, but the air stream is cut off by the solid plate between the holes. As the rate of rotation of the disc is gradually increased a low-pitched sound is heard when the puffs of air succeed one another at the rate of about sixteen per second, and as the rate of succession increases the sound becomes a well-marked *musical tone*, and the *pitch* of the tone is found to rise and fall with the number of puffs in a second which have caused it. If, instead of the single tube *m*, two tubes were used to convey the blast of air simultaneously through two different holes, the pitch of the sound would not be altered but its loudness would be increased, because

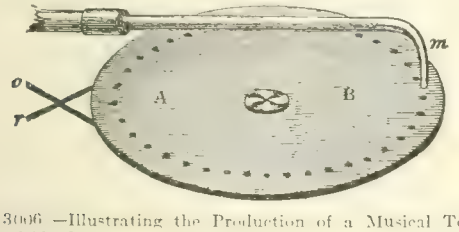

FIG. 3006.—Illustrating the Production of a Musical Tone by Puffs of Air through a Perforated Rotating disc. (After Tyndall.)

the two forces leading to condensation of the air would be added together. The demonstration of the laws of sound production in air owes much to an instrument called the *siren*, which is essentially elaborated from the perforated rotating disc.

The Range of Pitch of Audible Sounds.—As already mentioned, physical vibrations do not so affect the ear as to give rise to a *sensation of sound* until they succeed one another at the rate of sixteen to twenty-four per second. As the rate of vibration is progressively increased the pitch of the tone is raised until it becomes a painful squeak, and it is said that for most persons vibrations become inaudible when they reach a frequency of 16,000 per second, though some ears are still impressed with sounds caused by 38,000 to 40,000 vibrations in a second. Some of the lower animals can probably hear tones produced by still more rapid oscillations. It is a familiar experience that when a sounding bell or whistle, as of a locomotive, rapidly approaches, its pitch seems to rise, and then to fall as it recedes. The reason for this variation is that the motion of the locomotive adds to or subtracts from the number of sound waves reaching the ear in a given time. In the rendition of music a much narrower compass is employed, beyond which tones cease to have a pleasing character. The droning note of the sixteen-foot organ pipe and the lowest bass of the piano (C_1) represent a vibration rate of thirty-three per second. The highest treble of the piano has a vibration rate of 4,224 per second. Finely trained ears can distinguish differences of pitch represented by only half a vibration per second. As to the number of vibrations necessary to produce the sensation of sound, it has been found that two or three vibrations excite the sensation of a mere stroke; four or five vibrations are necessary to give a tone; and some twenty to forty are required to develop the full musical qualities of a tone. With like intensity of sensation, deeper tones require fewer vibrations but longer time to excite tone perception (de Groot). Thus from a physical scale representing aërial vibrations of indefinitely various rapidity the mind selects and appreciates as *sound* a small fraction, about a range of eleven octaves, and receives esthetic pleasure from a still narrower range of about seven octaves.

Summary.—The foregoing discussion may be summarized in the statement that *simple tones are due to waves which are produced by the pendular vibration of the particles of elastic bodies. The intensity of the sound sensation increases as the square of the amplitude of vibration, and the pitch of the sound rises in proportion to the rate of vibration.*

The Origin of Sound Quality. Overtones.—It is but seldom that sonorous bodies are confined to the simple pendular vibration of their particles; but the sound wave is the resultant of several vibrations of different rates simultaneously imparted to the moving particles. When a stretched string is plucked or bowed at its middle it vibrates throughout its whole length, the greatest amplitude of movement being at the middle point, which moves to and fro like a pendulum. The muscial note so produced is the lowest in pitch which the string is capable of giving. If the cord is held at its middle, or simply touched there with a feather, and a bow is drawn across one of the segments, vibration is renewed; but now the string divides, as it were, into two halves with a point of rest, or a "node," between. Each internode or "ventral segment" is half the length of the whole string, but its vibration is twice as rapid. The note given out is therefore the octave of that produced in the first instance. If the feather be applied at a point one-third the distance from one end, bowing the smaller segment will cause the string to break up into three equal vibrating parts, separated by two nodes or points of rest. In a similar way the string may be caused to vibrate in four, five, etc., segments. In each case the rate of vibration is as many times that of the whole string as there are segments of vibration. It is not necessary to keep the feather applied after the node is once formed.

The relative immobility of the nodes is illustrated by placing over the string a series of paper riders; when the string is thrown into vibration the strips of paper are violently displaced along the ventral segments but retain their position at the nodes (see Fig. 3007). It is not possible to make a string vibrate as a whole without at the same time its breaking up, to a greater or less degree, into its vibrating segments. The result is that the oscillation of any particle is not a simple pendular movement, but is the algebraic sum of an

indefinite number of such movements. The sound which is heard is a note in which are contained as many

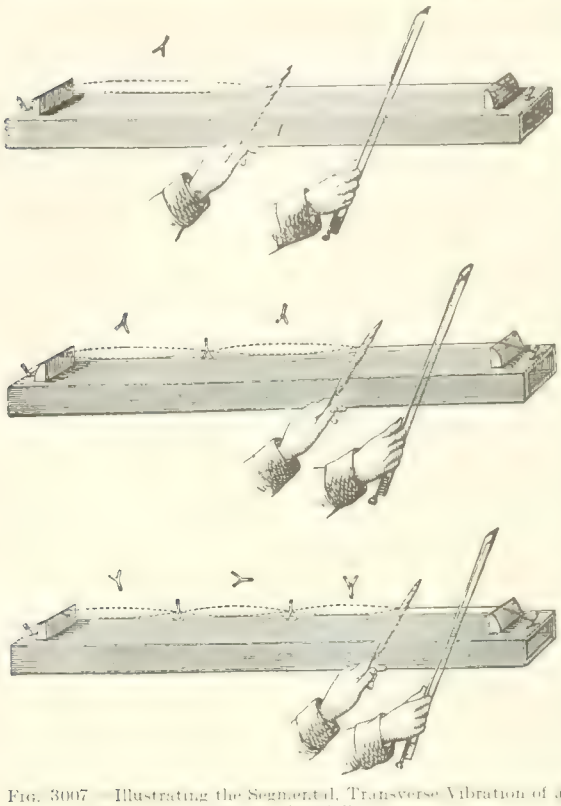

Fig. 3007.—Illustrating the Segmental, Transverse Vibration of a String. (Tyndall.)

simple tones as there are separate rates of vibration. The tone produced by the movement of the string as a whole, which is the slowest rate of vibration, is known as the *fundamental tone*. The various tones produced by the segmental vibrations are known as *overtones*, *upper partials*, or *harmonic sounds*. The *pitch* of the compound note is identical with that of its fundamental tone. But the blending of the various segmental vibrations with the primary results in an extraordinary esthetic modification of the sound, for thereby its *quality, timbre, or clang tint* is determined. Different sound-producing bodies may give out notes in which the number of upper partial tones is different. Thus, the notes of the flute or clarinet may contain but two or three harmonics while those of the reed organ pipe are very rich in them, containing often as high as twenty overtones. The deeper notes of the piano are rich and the higher are poor in harmonics.

The same may be said of the human voice. The esthetic attributes of the speaking voice, so unfortunately neglected in the United States, depend chiefly upon its overtones whose number decreases as the pitch of the fundamental is raised.

The quality of a note is altered not only by the presence in it of a definite upper partial but also by the mere independent change in intensity of this. It is obvious that the range of quality differences in sounds is without limit.

These facts may be summarized by saying that *the quality of a compound tone depends upon the number, order, and relative intensities of its constituent partials.* Thus, a violin, a cornet, and a piano, though sounding a note of the same pitch, would never be mistaken for one another. But were all their overtones obliterated the three instruments would be indistinguishable to the ear.

As already indicated, the vibration rates of the fundamental and its harmonic overtones have the ratios 1, 2, 3, 4, 5, etc. As will be seen later, an important sound element is the *inharmonic* overtone whose vibration rate is not a simple multiple of the fundamental.

The brilliancy and richness of musical notes is dependent on their wealth of upper partials. It is believed that a sound-producing body, like a stretched string, does not send to the ear a separate set of waves representing each of its segmental vibrations, but all the waves aroused by it fuse together into a single series of waves of peculiar form. Such a composite wave may be represented graphically by depicting under one another a series of waves having two, three, four, etc., times the rate of succession of the curve indicating the fundamental tone (Fig. 3008). If a vertical line be drawn across the series representing the vibration rates of the various tones, and an algebraic addition be made of the distance of each point of intersection above or below the line of rest, the result will determine the position of the composite wave on the same vertical. It is evident that the *form* of the composite wave must change with every change in the number and relative prominence of the overtones; and the movement imparted by it to the tympanic membrane, and the wave generated in the labyrinthine fluids (see below) must have corresponding differences. Notes of different quality are produced by composite air waves of different forms. But waves differing

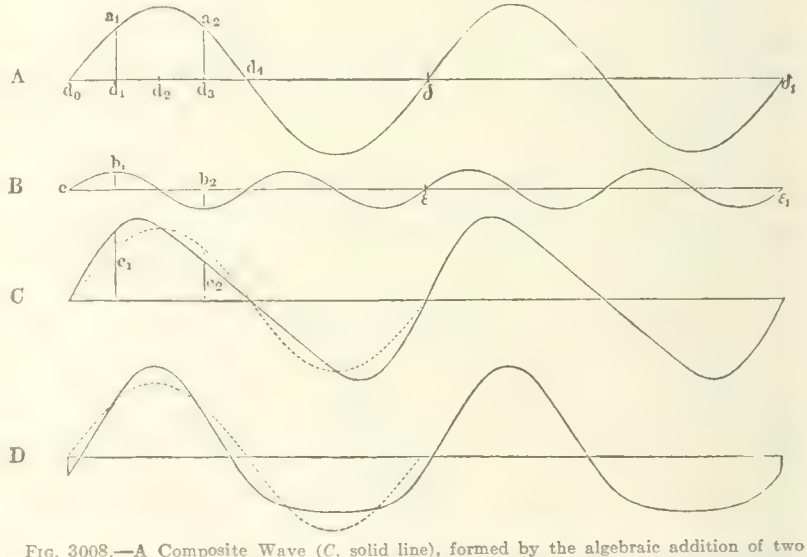

Fig. 3008.—A Composite Wave (*C*, solid line), formed by the algebraic addition of two simple pendular vibrations, *A* and *B*. *A* and *B* are in the same phase, but if curve *B* is moved to the right until *c* of *B* coincides with *d'* of *A*, the phases of the curves will be different and their addition will give curve *D* (solid line). Such change of phase, however, does not change the musical quality of the composite note. The dotted lines in *C* and *D* are identical with the curve in *A*. (After Helmholtz.)

somewhat in form may still produce notes of the same quality; for if, in the graphical figure, one or more of the curves representing simple tones be slid to the right or left, the form of the composite wave will thereby be changed, but not the quality of the sound produced by it. In other words, change of "phase" of the partial tones does not alter the quality of the note. The auditory apparatus analyzes composite tones into their simple pendular vibrations and thus distinguishes between them regardless of the form which the composite air wave may assume.

In binaural hearing, according to some observers, lateral localization of sounds is facilitated by perception of the minute difference of phase with which sounds from the side enter the two ears.

Conditions Determining the Kind of Overtones.—The series of overtones accompanying the fundamental varies under definite conditions. Thus, in a metal rod fixed at both ends the longitudinal vibrations set up by rubbing the rod lengthwise produce tones whose vibration numbers are to each other as the odd numbers 1, 3, 5, 7, etc. The tones of a rod free at both ends have vibration rates proportionate to the even numbers 2, 4, 6, 8, etc. In a stretched string the order of the overtones depends upon the place at which the string is plucked or struck. In general, it may be said that no overtone is heard which requires for its production the existence of a node at the point plucked or struck.

Difference between Noise and Music.—Sound sensations may be divided into two groups, *musical tones* and *noises*. The requisite for the former is that the vibrations that produce them shall be *periodic*, that the motions shall repeat themselves at regular intervals. Irregularity of the vibration period or rapid breaks from one periodic motion to another produce the sensation of "noise." The singing voice restricts itself chiefly to the musical notes formed by periodic vibration of the vocal cords; but in articulate speech the distinguishing consonantal sounds are chiefly noises.

Sympathetic Vibration. Resonance.—Every elastic body is capable of *sympathetic vibration;* that is, air waves beating upon it at its own natural rate of vibration set it into corresponding motion. In the same manner a heavy pendulum may be forced into violent movement by exceedingly light taps with the finger, the only necessary condition being that the impulses imparted by the finger be exactly timed to the periodic motion of the pendulum or to some multiple of it. A body capable of sympathetic vibration with some particular tone is set into vibration by that tone, and reinforces or magnifies it whether the tone exists alone or as the fundamental of a complex note, or is contained in the latter simply as an upper partial. The property of increasing the intensity of sound by sympathetic vibration is known as *resonance*. The tone of a tuning fork held in the fingers is scarcely heard, but becomes plainly audible when the stem is touched to a wooden table top. Forks used for experiment are usually attached to special "resonance boxes." The sound of the pianoforte owes its volume to the sympathetic resonance of its sounding board and the air contained in the instrument. Confined bodies of air are, on account of their low density, especially easily set into sympathetic vibration. Helmholtz constructed and used as resonators a series of hollow brass spheres with a perforated conical projection at one pole for insertion in the ear, and a larger opening diametrically opposite (Fig. 3009). The size of the spheres was graduated so that the fundamental tone of the contained air body represented various determined vibration rates. Each resonator picks out from a compound note, sounded near, that upper partial which is its own fundamental tone and greatly magnifies the intensity of that particular overtone. In this way a complex musical note may be analyzed into its constituent simple tones. Conversely, Helmholtz was able to reconstruct a complex note by simultaneously sounding a series of tuning forks, and appropriately regulating the intensity of the various simple pendular vibrations by means of resonators.

The vowel sounds of the human voice owe their difference of quality to the adjustment in size and shape of the resonant air chambers above the vocal cords by which now one, now another set of overtones is magnified. In descending the transition from the "head" to the "chest" voice is marked by vibration of the chest-wall indicating that the thorax has assumed the function of a resonance box.

That apparently simple tones are actually made up of a number of partials, having rates of vibration which form simple multiples of the fundamental tone, may easily be demonstrated at the open piano. If any note, as C in the base clef, be struck while the key of its octave *c* is depressed, and then the struck string be damped, it will be found that the octave *c* rings out with its proper note. So in turn the *g* above that, the second octave, and the *e* above that, may be made to sound when the lower C is struck, because each of these strings is so tuned that its fundamental note has the same vibration rate as one of the overtones of the lower C, to which it responds by sympathetic resonance. A note sung near the piano may, in the same way, be more or less completely analyzed into its component tones.

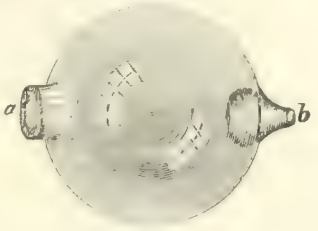

Fig. 3009.—The Resonator of Helmholtz.

The organ of hearing certainly has some such power of musical analysis, for some cultivated ears are not only able to follow a special instrument in a playing orchestra, but can even distinguish the overtones in the notes produced by it.

Inharmonic Overtones.—All overtones thus far considered are produced by vibrations which are simple multiples of the rate of the fundamental tone. Thus, the vibration rates of a series of upper partials may be two, three, four, five, etc., times that of the fundamental, or the vibration rate of the upper partials may be represented by the series of odd or even numbers, as the case may be. Such vibrations do not interfere with one another or with the fundamental tone, and their union produces on the ear an agreeable effect which gives them their name of *harmonics*. Harmonic upper partials are, according to Helmholtz, particularly characteristic of stretched strings and narrow organ pipes. But most elastic bodies when caused to vibrate give rise also to partial tones which are not exact multiples of the fundamental, and which may be termed *inharmonic* upper partials. The high-pitched jingle heard when a tuning fork is first struck represents the inharmonic upper partials of the fork. Stretched membranes have a great number of such inharmonic overtones, a fact which is of great importance in the function of the tympanic membrane. Inharmonic upper partials, as might be expected, rapidly die out in a note of which they form a part, because the vibrations causing them are antagonized by one another and by the stronger harmonic vibrations. For this reason the development of a well-marked fundamental tone is repressed in structures (like the tympanic membrane) which easily produce inharmonic overtones.

Interference of Sound. Beats.—Any source of sound, as a tuning fork, may be imagined as sending out from itself a series of waves of alternate condensation and rarefaction (see Fig. 3005). If a second tuning fork, having the same pitch, is brought near the first, the motion imparted to the air particles will be a resultant

of the two forces. If the forks vibrate in such order that the condensation or rarefaction produced by each simultaneously engages the same air particles, each of these conditions will become more intense and the sound will be *louder*. The forks are then said to vibrate in the same phase. But if one fork in its movement precedes or follows the other by *one-half* a vibration, then the phases of condensation from one tuning-fork correspond with those of rarefaction from the other, and the result is *silence*. Interference of

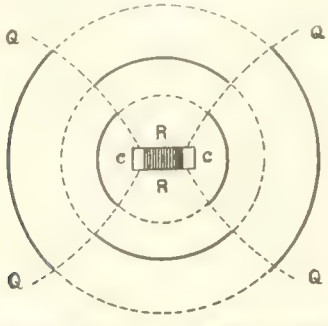

Fig. 3010.—Looking Down on the Prongs of a Tuning Fork in Action, as the prongs move apart phases of condensation are set up in the segments C and C, while phases of rarefaction are simultaneously produced in R. and R. When the prongs move toward each other the situation of the phases is reversed. Along the lines Q Q Q Q the phases of rarefaction and condensation balance and the result is silence. (After Mayer.)

sound waves may be demonstrated in the vibrations emanating from a single tuning fork. Thus, Fig. 3010 represents such a fork as seen from above.

When the vibrating prongs move away from each other a phase of condensation is imparted to the air in the sectors E and is propagated laterally as well as directly outward. But the same movement of the prongs which condenses the air in C rarefies it in R. The waves, or phases, of condensation and rarefaction intermingle, and along the lines Q they exactly neutralize each other, the result being silence. Of course phases of condensation and rarefaction in any sector alternate with each motion of the prongs. These facts may be illustrated by slowly revolving a sounding tuning fork opposite the auditory meatus. When the prongs are turned so that the extension of any line Q enters the ear the tone is greatly enfeebled. A very important outcome of this principle of interference is manifested when two tones slightly different in pitch are sounded together. Let a prong of one of two vibrating tuning forks be loaded with wax; its vibrations will thereby be made slower and its pitch lowered. Though the forks may start vibrating in the same phase, the vibrations of one fork will outpace those of the other until a phase of condensation of the first will correspond to a phase of rarefaction of the second, and the result will be perfect or comparative silence. The unequal rate of vibration continuing, like phases will again fall together and the sound will become louder than from either fork alone. An alternate augmentation and diminution in the intensity of the sound is the result. These sound pulses are known as *beats*, and they are the most potent cause of discord in music. Fig. 3011 is a diagram representing two series of separate pendular vibrations, AA′ and BB′, the pitch of the latter being slightly higher. The more rapid vibrations of BB′ periodically overtake those of AA′ and an algebraic addition of the displacement of the air particles gives the third curve CC′. When the partial tones are in the same phase the sound is greatly increased as at C and C′. When the partial tones are in opposite phases they neutralize each other and there is silence, as at E and E′. The frequency of the beats is represented by the distance between C and C′ or between E and E′. When two notes not included in a perfect chord are sounded on the piano, beats are heard not only from the interference of the fundamental tones, but of the upper partials as well. It is the absence of beats in tones that should be in harmony, as those of the major chord, that determines the instrument to be in tune. When two tones produce beats, the number of beats in a given time is equal to the difference between the number of vibrations involved in the two tones in the same time. For example, a tone produced by 256 vibrations in a second sounded with one of 228 vibrations would give twenty-eight beats in a second. It is evident that the frequency of beats may be increased either by increasing the interval between the tones or by striking tones of the same interval in a higher part of the scale. Beats which are not too frequent—from four to six in a second—have important musical value; but when they number thirty or forty in a second they become exceedingly disagreeable, irritating the ear in a manner analogous to the effect of a flickering light on the eye. It is obvious, however, that if the sensation aroused by one beat lingers until the next beat falls upon the ear, the sensations will be fused and a new tone will be produced. The following table from Mayer's little book on Sound shows the duration of the beat-sensation and the number of beats per second necessary to form a continuous tone at different parts of the musical scale:

Note.	Vibrations.	Beats.	Duration.
c	64	16	$\frac{1}{16}$ sec.
C	128	26	$\frac{1}{26}$ sec.
e	256	47	$\frac{1}{47}$ sec.
g	384	69	$\frac{1}{69}$ sec.
c	512	78	$\frac{1}{78}$ sec. *

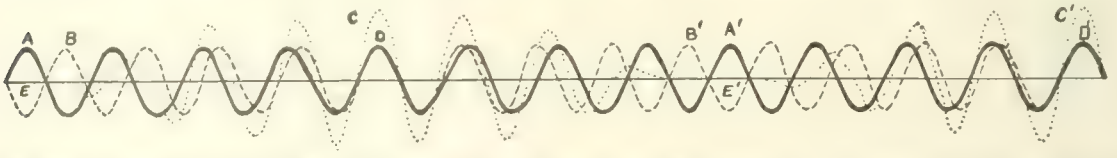

Fig. 3011.—The solid line AA′ develops 13 waves while the broken line BB′ completes 14. The algebraic addition of the two curves is represented by the dotted line CC′. At A and A′ there is complete interference of the pendular vibrations and the dotted line C comes to rest: at D and D′ there is maximum summation of the partial tones and the dotted line at C and C′ shows maximal departure from the position of rest. A single beat is represented by the fluctuation of the dotted line between C and C′ or between E and E′.

Harmony and Discord.—Tones are *concordant* or *harmonic* when they produce no beats on being sounded together; they are *discordant* when beats are produced, and the painful sense of dissonance increases in intensity up to about thirty-three beats per second. Perfect concord is obtained by blending tones whose vibrations are to one another as small whole numbers. Thus, in the major chord C E G c the vibration numbers are 132, 165, 198, 264, their ratios are 4, 5, 6, 8.

* The vibration rate of middle *c* is usually taken as 264.

If tones the ratio of whose vibration rates can be represented only by large whole numbers are combined, a discord is formed, for the reason that their upper partials interfere with one another and cause beats; there is no especial virtue in the small integer.[2]

Thus in the discord C D E the vibration numbers are 132, 148.5, 165, which are not reducible to small whole numbers.[3]

Resultant Tones.—When two powerful tones of different pitch are sounded together there may be heard in addition a third tone of much lower pitch than either. This is a *resultant* of the two primary tones and has been called a *difference tone*, because its pitch corresponds to a vibration rate equal to the difference of rates of the two primary tones. "Difference tones," though having the same numerical relations as "beats," are not to be confused with the latter. As two tones may generate a third which represents the difference between their vibrations, so, it was predicted and demonstrated by Helmholtz, they may give rise to *summation tones* whose pitch is determined by the *sum* of the vibrations of the primary tones. The vast complexity of the system of aërial waves to whose impress and analysis the ear is sensitive and capable, is well expressed by Tyndall:[3] "In the music of an orchestra, not only have we the fundamental tones of every pipe and of every string, but we have the overtones of each, sometimes audible as far as the sixteenth in the series. We have also resultant tones; both difference tones and summation tones; all trembling through the same air, all knocking at the self-same tympanic membrane. We have fundamental tone interfering with fundamental tone, overtone with overtone, resultant tone with resultant tone. And, besides this, we have the members of each class interfering with the members of every other class. The imagination retires baffled from any attempt to realize the physical condition of the atmosphere through which these sounds are passing."

Out of the wealth of literature upon the physics of sound, mention may be confined to the work of Helmholtz: "Die Tonempfindungen," translated by Ellis, "Sensations of Tone," etc., which covers the field of physiological acoustics. Also, the lectures of Tyndall on "Sound," Appleton, 1877, are full of clear beauty on the physical side.

Anatomy and Physiology of the Ear.—Detailed description of the structure of the various parts of the ear may be found under appropriate captions. In this section anatomy and histology will receive as little attention as is consistent with clear exposition of functions.

The *organ of hearing* is usually described as consisting of the following divisions: 1. *The external ear*, composed of the *pinna* or *auricle* and the *external auditory meatus*. 2. The *middle ear*, including the tympanic cavity with its contents, the communicating Eustachian tube, and the tympanic membrane. 3. The *internal ear* or *labyrinth*, including the vestibule, cochlea, and semicircular canals, with their corresponding membranous contents, and the *ductus endolymphaticus*.

The *pinna* or *auricle* (Fig. 3012) has less functional importance in man than in some of the lower mammals, as the deer, in which its trumpet shape is especially adapted for the collection of waves of sound. The extreme mobility of the auricle in such animals must make it of use in locating sounds, a function important to the preservation of its life from enemies. Even the human auricle, and especially the *concha*, must serve an important use in the collection of sound waves.

The *external auditory meatus* or *canal* (Fig. 3012) serves the purpose of conveying with undiminished intensity the sound collected by the auricle to the tympanic membrane, while allowing this structure to be buried at a safe distance from the surface. Sound waves produced in the open air radiate in all directions and rapidly diminish in intensity (the decline in intensity is proportional to the square of the distance traversed). When sound is prevented from radiating, as when one whispers into the open end of a tube, it is conducted for extraordinary distances. This is the principle on which the effectiveness of the stethoscope depends. The relations of the parts of the human external ear, the *tragus* and *antitragus*, the oblique direction of the meatus and the bend in its course, are admirably adapted for the protection of the tympanic membrane from external violence.

The external auditory meatus acts as a resonator for tones in unison with its own fundamental, whose pitch corresponds to a vibration rate of about 3,000 per second. The shrill intensity possessed by certain tones near the upper limit of the musical scale, as the chirp of a cricket, is due to the sympathetic resonance of the auditory canal (Helmholtz).

The *middle ear* or *tympanum* (Figs. 3012–3018) is an air-holding cavity of irregular shape in the petrous bone, and it is broader behind and above than it is below and in front. Posteriorly it is in open communication with the complex system of air cavities in the mastoid bone known as the *mastoid antrum* and the *mastoid cells*. A considerable portion of the cavity lies above the level of the tympanic membrane and is known as the *attic*. It is separated from the brain

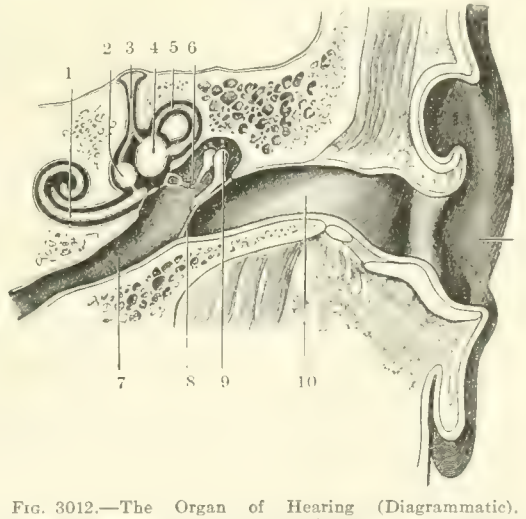

Fig. 3012.—The Organ of Hearing (Diagrammatic). 1, Cochlea; 2, sacculc; 3, ductus endolymphaticus; 4, utricle; 5, semicircular canal; 6, tympanic cavity with chain of ossicles; 7, Eustachian tube; 8, membrana tympani; 9, recessus epitympanicus; 10, external auditory meatus. (Cunningham.)

cavity by a thin plate of bone (*tegmentum tympani*). It is easy to see how suppurative inflammation of the middle ear not only may invade the mastoid cells but, by absorption of the thin roof of the cavity, and in other ways, may make *otitis media* the commonest source of pyogenic affections of the brain.[1] Anteriorly the tympanum is continuous with the pharynx through the Eustachian tube (Fig. 3013). The inner wall of the cavity is formed chiefly by part of the bony envelope of the internal ear. The surface of the inner wall is pierced by two apertures, the *fenestra ovalis*, or oval window, and the *fenestra rotunda*, or round window, leading into separate divisions of the cavity of the bony labyrinth.

In life each fenestra is covered by a thin sheet of membrane, and the foot of the *stapes* (see below) is fastened by a ligamentous fringe in the oval window. The cavity of the tympanum is lined by mucous membrane continuous with that of the Eustachian tube and the pharynx, and the membrane, like that

of the Eustachian tube, is ciliated except over the surfaces of the ossicles and the tympanic membrane.

The *tympanic membrane or drumskin* (Figs. 3012–3014), separates the tympanic cavity from the auditory canal. It is a somewhat oval disc whose longer axis is directed from behind and above downward and forward, and whose length is about 9 mm. The membrane is inserted obliquely to the axis of the meatus, so that the floor of the latter is longer than its roof. The membrane varies considerably in its

Fig. 3013.—Left Membrana Tympani and Chain of Tympanic Ossicles, seen from the Inner Aspect. 1, Recessus epitympanicus; 2, body of incus; 3, short process of incus; 4, segment of incus; 5, chorda tympani; 6, pyramid with tendon of stapedius muscle; 7, foot of stapes; 8, sup. ligament of malleus; 9, head of malleus; 10 and ligament of malleus; 11, handle of malleus; 12, tensor tympani muscle; 13, cochleariform process; 14, osseous part of Eustachian tube. (Cunningham.)

physical characters in disease, but normally it is semitransparent and of a pearly luster to otoscopic vision (Fig. 3014). It is composed of an outer layer of thin skin, an inner layer of mucous membrane, with a coat of chiefly fibrous tissue between. The greater number of the fibers of this middle layer (*membrana propria*) radiate from near the center to the periphery of the membrane; but there are also circular fibers of elastic tissue which are most numerous in a ring near the attached margin of the membrane. The surface of the drumskin is not flat, but is funnel-shaped with the apex of the funnel pointing inward, a position determined by the attachment of the handle of the malleus. Moreover, the radial lines of the membrane are not straight, but are slightly curved

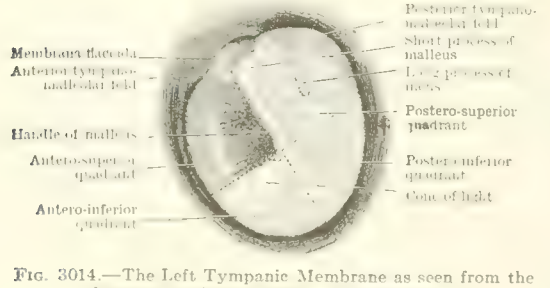

Fig. 3014.—The Left Tympanic Membrane as seen from the External Auditory Canal. (Cunningham.)

with the convexity outward, this shape being partly due to the tension of the circular elastic fibers. A small segment in the upper part of the membrane, *membrana flaccida*, or *Shrapnell's membrane*, lacks the tenseness of the rest of the structure. When light is thrown upon the normal tympanic membrane, a bright reflection (known as the pyramid of light) is seen in its lower anterior quadrant. The apex of the bright triangle is at the tip of the manubrium, and its base is on or near the periphery of the membrane.

Auditory Ossicles.—The vibrations of the tympanic membrane are transferred to the *fenestra ovalis* of the labyrinth by a chain of three little bones: the *malleus* (hammer), *incus* (anvil), and *stapes* (stirrup), the so-called *auditory ossicles* (Figs. 3015 and 3016.) The *malleus* has a rounded head grooved on one side for articulation with the incus, a short neck and a long handle or *manubrium*, which is inserted in the tissue of the tympanic membrane from a point on its upper periphery to a little below its center. The *processus brevis* of the malleus is a low conical projection which rises from the top of the manubrium and presses directly against that segment of the tympanic membrane which lies immediately below the *membrana flaccida*. These parts can usually be seen on inspection with the ear speculum (Figs. 3012, 3013, 3014). The *processus gracilis* or *processus folianus*, long and slender, arises from an eminence just below the neck of the malleus, and, passing forward and outward, is inserted in the Glaserian fissure in the wall of the tympanum. The malleus is held in position partly by ligaments. The *superior* or *suspensory ligament* passes downward and outward from the roof of the tympanum to be inserted into the head of the malleus. The main portion of the *anterior ligament* (Fig. 3017) is attached to the neck of the malleus just above the *processus gracilis;* it embraces the latter and, passing forward, finds its origin in the anterior wall of the tympanum and in the Glaserian fissure. Another division of this ligament, the *external ligament*, arises

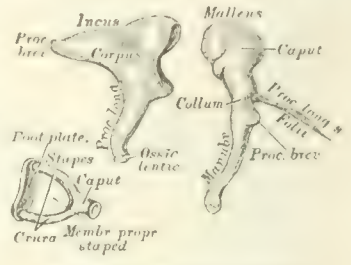

Fig. 3015.—The Three Ossicles. (After Heitzmann.)

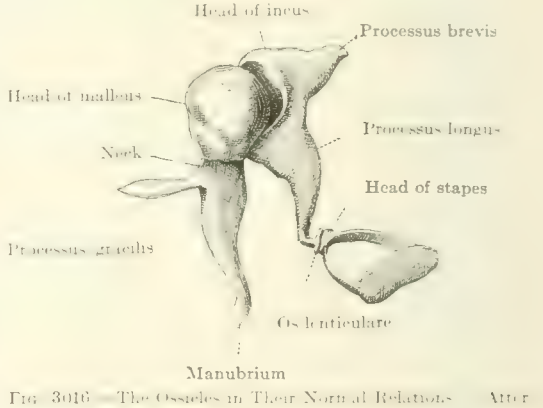

Fig. 3016.—The Ossicles in Their Normal Relations. (After Henle.)

and is attached more externally than that just described. The ligaments of the malleus serve to keep its head in position (Figs. 3017, 3018). The external ligament being attached above the axis of rotation of the hammer, prevents the head of this bone from moving too far inward, and the manubrium from being pushed too far outward. The superior ligament, owing to its oblique course, restrains the head of the hammer from moving too far outward.

The *incus, ambos*, or anvil bone, is shaped somewhat like a bicuspid tooth. Its body is hollowed on the surface and covered with cartilage for articulation with the head of the malleus. It has two processes, a *long*

and a *short*, which project at right angles to each other. Their respective lengths are about four and three millimeters. When in natural position, the long process descends nearly parallel with the manubrium, but it has less than three-fourths the length of the latter. The free end of the long process is turned sharply inward at right angles, and terminates in a rounded projection, the *os orbiculare* or *lenticulare*, which is provided with cartilage for articulation with the head of the *stapes*. The short process is conical in shape and is thicker than the long process. It has a horizontal position, and is attached by a thick ligament to the posterior wall of the tympanum.

The *stapes* articulates with the end of the long process of the incus; its plane is horizontal and about at right angles to that process. It measures about three to four millimeters in length by about two and one-half in breadth. The base of the stirrup bone is set in the *fenestra ovalis*, an aperture measuring about three by one and one-half millimeters, and is held in position by a narrow membrane made up of radial fibers of connective tissue (Fig. 3019). When in position, the innerface of the base of the stapes is covered with lymphatic endothelium and is washed by the perilymph of the internal ear; the outer face, like the other ossicles and the wall of the tympanum, is covered by thin mucous membrane.

Movements of the Ossicles.—The *malleus-incus* articulation is so arranged that with outward movements of the manubrium the head of the malleus glides freely in the joint; but the lower margins of the articulating surfaces project in such a way that the prominences catch upon each other and interlock when the manubrium is moved inward. Thus, in inward movements of the tympanic membrane and its attached manubrium, the malleus and incus move together like one rigid piece of bone, the motions of the manubrium and of the long process of the incus being parallel. In the outward movements the locking teeth or projections are probably, under ordinary conditions, still kept in apposition through the elastic reaction of the ligament

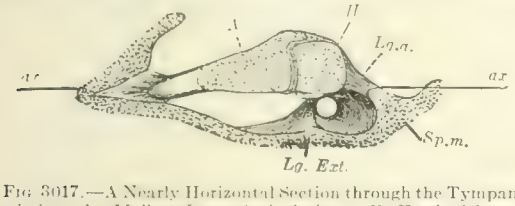

Fig. 3017.—A Nearly Horizontal Section through the Tympanum, including the Malleus-Incus Articulation. *H*, Head of hammer, inner surface; *A*, anvil or incus, whose short process is held by ligaments in a bony niche: *Sp. m.*, spina major of tympanic wall; *Lg. a.*, anterior ligament; *Lg. Ext.*, external ligament. The line *ax–ax* represents the axis of rotation of the two ossicles. (After Hensen.)

and the stapedial attachment of the incus. Should, however, the tympanic membrane be forced unduly outward, as by increase of pressure within the tympanum or rarefaction of the air in the auditory meatus, the incus only follows the malleus for a certain distance, the latter completing its motion by gliding in the joint. There is thus no danger of the stapes being torn out of the oval window. Of the malleus-incus articulation Helmholtz says: "In its action it may be compared with the joints of the well-known Brégnet watch keys, which have rows of interlocking teeth, offering scarcely any resistance to revolution in one direction, but allowing no revolution whatever in the other." The hammer and the anvil, suspended by their ligaments, move freely about an axis one end of which is found at the origin of the anterior part of the anterior ligament of the malleus, and the other end in the origin of the ligament which is continuous with the short process of the incus (Fig. 3017).

In inward motions of the tympanic membrane (and probably under ordinary conditions in outward motions as well), the ossicles move like a single bone about the axis of suspension. The three bones may be likened, then, to a single rigid lever of peculiar form. The power is applied to this lever at the tip of the manubrium, the effect is produced at the footplate of the stapes. Observation shows that the fulcrum is found at the end of the short process of the incus. From the latter point the distance measured to the *umbo* or tip of the manubrium is about one and one-half times the distance from the fulcrum to the end of the long process of the incus. Therefore, motions imparted to the stapes can have but two-thirds the amplitude of those arising at the umbo; but, according to the principles of the lever, the former movements have one and one-half times the force of the latter. It will be noticed that a large proportion of the mass of both anvil and hammer is found above their axis of rotation; this upper portion acts as a counterpoise to the parts below which are directly concerned in the lever action. The bony lever being thus balanced, it is less difficult to understand its known sensitiveness to impulses that are inconceivably weak. The tense tympanic membrane, by reason of its funnel shape, resists strong inward compression; hence the stapes is prevented from being pressed too far inward. The maximum amplitude of motion of the end of the long process of the incus is very small, being only about $\frac{1}{15}$ to $\frac{1}{11}$ millimeter, while that of the center of the tympanic membrane is about $\frac{1}{12}$ to $\frac{1}{9}$ millimeter.

The great rapidity of aërial vibrations to which the chain of ossicles can respond suggests that it conducts the sound pulses as molecular or longitudinal vibrations, as a rigid rod of wood transmits the tick of a watch. But Helmholtz has shown reasons for believing that the functional movements of the ear bones is molar, that they oscillate as a whole, the chain moving in a body with each impulse. It is open to suspicion that the upper limit of the scale of pitch may be determined by the superior rate of vibration to which the chain of bones is capable of responding. The sole purpose of this apparatus of the middle ear is to transmit exactly the variations of pressure in the air of the external auditory meatus to the perilymph which bathes the foot of the stapes; in other words, to convert air waves into a similar series of water waves. As put by Helmholtz: "The mechanical problem which the apparatus within the drum of the ear had to solve was to transform a motion of great amplitude and little force, such as impinges on the drum skin, into a motion of small amplitude and great force, such as had to be communicated to the fluid in the labyrinth." The adaptation of the apparatus of the middle ear to this end is worthy of careful consideration. In the first place, it will be noticed that the area of the fenestra ovalis which receives the impulses of the stapes is but a small fraction of the surface of the tympanic membrane on which the air waves impinge, the latter area being some fifteen to twenty times greater than the former, so that the energy of air motion is, in a fashion, concentrated. In the second place, as previously observed, the lever mechanism of the auditory ossicles is such that the movements of the end of the long process of the incus have two-thirds the amplitude of those of the tip of the manubrium, but about one and one-half times their force. It should also be noticed that the membrane fastening the foot of the stapes in the fenestra is somewhat less tense on the upper side, so that the top of the oval footpiece has a freer motion than the bottom, and, as the end of the incus process moves somewhat upward and inward, the head of the stirrup rises slightly with inward motions. In other words, the stapes itself forms an independent lever, of which the long arm is the height of the stirrup and the short arm less than the breadth of its footpiece, by which the motion imparted by the incus is further reduced in amplitude but increased in power. In the third place, it has

been demonstrated by Helmholtz that the shape of the tympanic membrane peculiarly adapts it for transforming weak movements of wide amplitude into strong ones of small compass. For this membrane is not a simple funnel depressed inwardly, but the radii are slightly curved with the convexity outward, a shape chiefly due, it is said, to the tension of the elastic circular fibers of the membrane on its inner face, these being most numerous toward the circumference.* Air waves beating upon this convexity flatten the curve somewhat, and their whole energy must be concentrated, with increased intensity, but loss of motion, near the central point of the membrane. The same effect is illustrated by the fact that when a string or rope is stretched horizontally between two points, no matter how tightly, it always sags in the middle; the weight of the cord, however slight, drags it down in a curve, and produces a corresponding traction on the points of support.

Special Properties of the Tympanic Membrane.—It is evident that any marked tendency of the transmitting apparatus of the middle ear to vibrate at a particular rate—that is, possession by it of a strong fundamental tone—would render impossible the conduction of aërial pulses in their actual proportion of intensity. Membranes have fundamental tones (see p. 26), whose pitch is determined by their area, thickness, and tension, but they differ from rods, strings, etc., in being less strictly confined to a single fundamental tone in their vibration. The tympanic membrane is peculiar in that it can hardly be said to have a definite fundamental tone. This is prevented probably both by reason of its structure and the peculiar form of its surface, and also because its oscillations are damped by the pressure of the malleus held in position by the other mechanisms of the tympanum. The membrane probably responds indifferently to a wide range of vibration-rates. It is said to move perceptibly with the pulse, with the act of swallowing; and at the beginning of sounds owing to contraction of the tensor tympani muscle (Köhler).

One important purpose subserved by the tympanic membrane is no doubt to guard from injury the delicate membranes of the fenestræ and other contents of the middle ear. The astonishing freedom of the normal membrane from foreign particles is probably due to a radial movement of its surface epithelium in the course of cellular renewal.

When the tympanic membrane is perforated or is even wholly removed, without destructive inflammatory changes in the middle ear, sounds are still heard, though usually with diminished loudness. An artificial drum inserted in the meatus occasionally improves hearing in the absence of the normal membrane, or when the transmitting mechanism is abnormally relaxed. It is said that it should be placed in contact with the malleus, and its mode of action seems to be to bring aërial vibrations to bear effectively upon the ossicles. A small wad of cotton has been employed with the same result.

When the tympanic membrane is absent, air waves beat directly upon the membranes of the fenestræ, and certain sounds may then be heard with increased loudness. But in the absence of the elaborate arrangement described above for abolishing sympathetic vibration of the sound-conducting mechanism, it is probable that the fenestral coverings are crude and inaccurate interpreters of the sounds beating upon them. Thus, a musician who had suffered loss of his tympanic membranes was no longer able to play his violin, probably because sounds of different pitch ceased to be perceived in their true relations of loudness (Dr. E. C. Rivers).

Hearing by Bone Conduction.—Just as the sound of a watch or tuning fork may be conducted through a wooden rod, so molecular vibrations may pass to the auditory apparatus through the bones of the skull. Such movements probably have the nature of the longitudinal vibrations discussed in a previous section (p. 21). If the stem of a sounding tuning fork be touched to the skull or held between the teeth the tone will be plainly heard, and the sound becomes louder when the ears are stopped. If the fork be held between the teeth until the sound dies away, the tone reappears upon closing one of the auditory canals and on the same side as the closure. A fork which has become silent to air conduction may still be heard if held between the teeth; and when the sound again dies away, it returns when the stem of the fork is inserted into the meatus.[5] Hearing by bone conduction occurs in the absence of the tympanic membranes, and even when the membranes covering the fenestræ of the internal ear are so altered by disease as to be ill adapted to transmit vibrations. Such vibrations are, probably, transmitted directly through the bony labyrinth to its contained fluid, though in the presence of the normal fenestral coverings and of the tympanic membrane the vibrations are, without doubt, taken up and transmitted by these structures. Closing the ears would then reflect and intensify the sound.

In deafness due to middle-ear trouble sound can still be plainly heard by bone conduction. The *audiphone* is essentially a sheet of some elastic material, as hard rubber, easily set into sympathetic vibration, which is held against the teeth to which it transmits vibrations that it has taken up like a sounding board.

In deafness due to disease of the internal ear vibrations conducted through the bones of the skull make no auditory impression. According to Egger,[6] even when there is deafness to skull vibrations, a tuning fork may still be heard and pitch recognized when it is applied to the bones of the extremities (olecranon, tibia). As this power fails when the part is made anemic by Esmarch's bandage, the author ascribes the sensation not to bone conduction, but to irritation of the auditory centers by way of the nerves of common sensation.

Eustachian Tube.—Any steady inequality of air pressure on the two sides of the tympanic membrane would evidently more or less interfere with the functional movements of this disc. As air is probably continuously absorbed from the tympanum and as external barometric pressure is ever varying, the drum of the ear needs some arrangement for the maintenance of an equilibrium of air pressure on the two sides of the tympanic membrane. Such a mechanism is found in the *Eustachian tube,* a somewhat trumpet-shaped canal which, beginning in the lower, anterior wall of the tympanum, runs downward, forward, and inward, and terminates in a slit in the side of the upper part of the pharynx (Fig. 3013). The Eustachian tube is lined, like the walls of the tympanum, with ciliated epithelium, the cilia working in such a way as to convey into the pharnyx such secretions as may be poured into the middle ear, as well as the foreign matter that may enter the canal from the pharynx. A consideration of the ordinary mode of infection of the middle ear from the pharynx suggests how important a rôle must be borne by the ciliated epithelium in the preservation of health.

The pharyngeal opening of the Eustachian tube is probably usually closed, but may be made to open by considerable increase of air pressure within the pharynx, as may be produced by closing the nose and mouth and either forcing air into the pharynx by strong expiratory movement or rarefying it by suction. In the former case air pressure within the middle ear is increased, in the latter it is diminished. When air is thus made to enter or leave the tympanum a sensation of a sudden snap and a dull crackling noise in the ear are experienced. The lower end of the tube is nor-

*Any fresh animal membrane, when laid over a circular frame and stretched by the pressure of the end of a rod applied to its center, will take on the shape of the tympanic membrane and preserve it in the dried condition.

mally opened during the act of swallowing, and it is at this moment that the intra- and extratympanic pressures are equalized. The well-known method of Politzer for inflation of the middle ear consists in forcing air into one nostril during the act of swallowing, while the other nostril and the mouth are closed.

Muscles of the Middle Ear.—There are two intrinsic muscles of the middle ear which serve to adjust the tension of its transmitting mechanism. Roughly speaking, they are antagonistic in action. The *tensor tympani* muscle is lodged within a groove which is just above and about parallel with the Eustachian tube (Fig. 3013). It terminates externally in a long tendon which bends nearly at right angles round the outer edge of the groove and is inserted into the handle of the malleus near the neck. Contraction of the tensor tympani thus pulls the tympanic membrane inward, renders it more tense, and somewhat dampens its vibrations (Fig. 3018). At the same time the toothed processes of the incus and malleus are brought closely together so that there can be no loss of motion in vibration of the ossicles, and the stapes is driven further into the oval window, increasing tension within the labyrinth. Opinion is somewhat divided as to the conditions of functional activity of the tensor tympani. The normal tone of the muscle probably gives it some constant tensor effect. It is said that the relaxed tympanic membrane, particularly after section of the tensor tympani muscle in lower animals,

Fig. 3018.—Diagram Representing the Mode of Displacement of the Ossicles under the Influence of the Contraction of the Tensor Tympani Muscles. (After Testut.) *a*, External auditory canal; *b*, tympanic cavity; *c*, vestibule of the inner ear; *d*, fenestra ovalis; 1, membrana tympani; 2, manubrium mallei; 2′, section of the long process of the malleus; 3, head of the malleus; 4, insertion of the tendon of the tensor tympani muscle; 5, vertical or long process of the incus; 6, head of this ossicle; 7, the stapes. The dotted lines indicate the positions which the ossicles and tympanic membrane will assume when the tensor tympani muscle contracts; the arrow shows the direction of this movement.

is thrown into sympathetic vibration with comparative ease, and is in this condition best adapted to respond to weak aërial impulses and to the periodic waves of musical notes. When the membrane is tense its vibrations are more or less damped and it is then best fitted to transmit with distinctness the irregular vibrations of noises and consonantal sounds. It would follow that the action of the muscle facilitates distinct appreciation of speech while it diminishes acuteness of hearing. According to Hensen[1] the tensor tympani muscle is reflexly excited to contract by the initial waves of a sound, resulting in a closer interlocking of malleus and incus, thereby preventing loss of motion in subsequent vibrations. But Osterman[7] has given reason for believing that the muscle is chiefly a protective mechanism called into play only or mainly by very loud and painful noises. Its action prevents oscillations of the tympanic membrane which would otherwise be of so great amplitude as to damage the ear.

The *stapedius* is a small muscle embedded in the inner wall of the tympanum near the fenestra ovalis. Its tendon, passing forward, is inserted into the neck

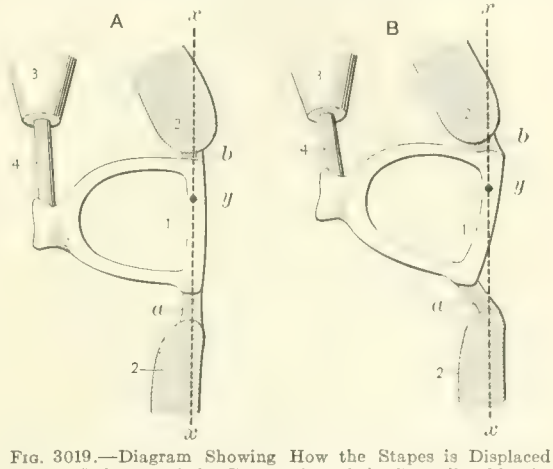

Fig. 3019.—Diagram Showing How the Stapes is Displaced under the Influence of the Contraction of the Stapedius Muscle. (After Testut.) *A*, Stapes in repose; *B*, stapes after the stapedius muscle has contracted. 1, Base or footplate of the stapes; 2, anterior margin of the fenestra ovalis; 2′, posterior margin of the same; 3, pyramidal process, giving exit to the tendon (4) of the stapedius muscle; *a*, anterior portion of the annular ligament; *b*, posterior and shorter portion of the same ligament; *xx*, anteroposterior diameter of the fenestra ovalis, passing through the footplate of the stapes in its two positions—*A*, when in repose, *B*, after the contraction of the stapedius muscle; *y*, the point through which the vertical line that represents the axis of rotation of the stapes passes.

of the stapes. Contraction of the muscle would have the effect of pressing the hinder part of the foot of the stapes either against the edge of the oval window or farther into the opening, and of withdrawing the forward part from it (Fig. 3019). The muscle may therefore be considered to diminish pressure within the labyrinth, causing the membrane of the round window to be drawn, on the whole, inward. Its action in these respects is the opposite of that of the tensor tympani. It is said that the stapedius is controlled by the facial and the tensor tympani by the fifth nerve.

A bundle of fibers passing backward from the anterior part of the tympanum to be inserted into the malleus just above the root of the processus gracilis has been described as the *laxator tympani muscle*. It will receive no further notice since Helmholtz and others consider it to be merely a ligamentous support for the malleus.

The Internal Ear or Labyrinth.—A description of the minute anatomy of the internal ear and a consideration of the clinical modifications of its functions are well set forth in the excellent treatise of Braun and Friesner, The Labyrinth, New York, 1913. The labyrinth is the seat of the sensory organ of hearing. It is composed of a complicated system of membranous tubes and sacs, the *membranous labyrinth*, in which terminate at particular points bundles of filaments of the auditory nerve. The membranous labyrinth is contained within a chamber, the *bony labyrinth*, hollowed in the petrous bone (Figs. 3020–3023). The osseous

tissue immediately surrounding the labyrinthine cavity is very dense and with care may be separated from the bone of looser texture about it. The cavity of the bony labyrinth (Figs. 3020, 3021) consists of a median part, the *vestibule*, which is prolonged posteriorly in the system of *semicircular canals* and anteriorly in the *cochlea*. The vestibule is a space which measures in man about one-fifth of an inch in diameter, and it is perforated on its outer wall by the oval opening known as the *fenestra ovalis*. The semicircular canals

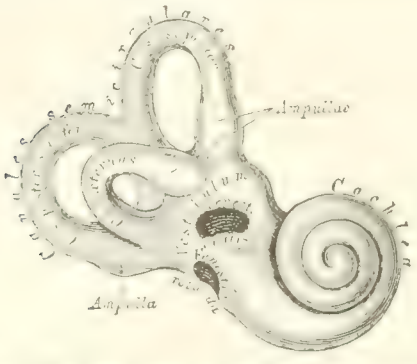

Fig. 3020.—The Bony Shell of the Labyrinth. (After Heitzmann.) ½.

are three tubes of circular section, known respectively as the anterior or superior, the posterior, and the external or horizontal semicircular canal. Their planes are about at right angles to one another, so that they occupy the three possible dimensions of space. Each canal is dilated at one extremity into a globular cavity which is known as the *ampulla*. The anterior and posterior canals unite near the ends not provided with ampullæ, and they enter the vestibule as a common tube. Anteriorly the vestibule is continued as a tube which is coiled upon itself two and one-half times, and which, from its resemblance to the shell of a snail, is known as the *cochlea*. The osseous cochlea (Fig. 3022) may be conceived as formed by a bony tube coiled about a bony central pillar, the

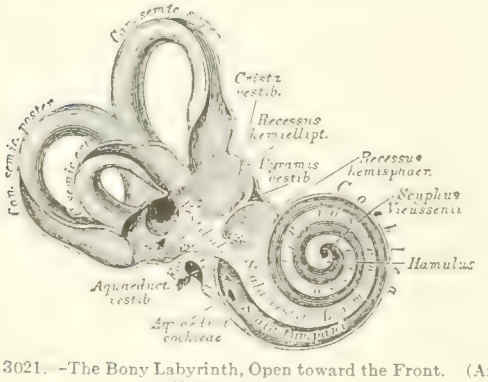

Fig. 3021.—The Bony Labyrinth, Open toward the Front. (After Heitzmann.) ½.

modiolus, which is of spongy texture and diminishes in diameter from the base to the apex of the cochlea. From the modiolus a bony shelf, the *lamina spiralis*, stretches into the cavity of the tube, incompletely dividing it into two tubular chambers, and winds round the central pillar like a spiral staircase. The separation of the spaces on either side of the *lamina spiralis* is rendered complete by membranous structures to be considered later. The tubular area on that side of the lamina spiralis which faces the apex of the cochlea is in free communication with the vestibule and is known as the *scala vestibuli*. The part of the canal which is on the opposite side of the lamina spiralis, facing the base of the cochlea, is known as the *scala tympani*, because it comes into relation with the tympanum at the fenestra rotunda (Figs. 3022–3025). In the upright position of the head the axis of the

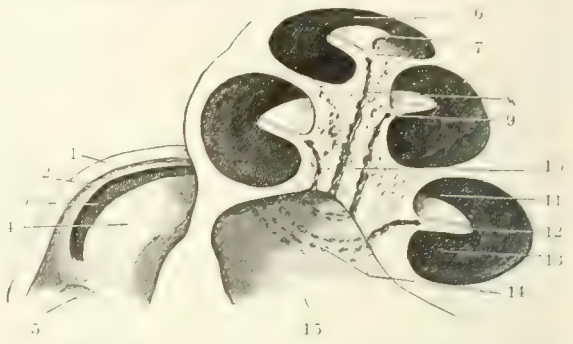

Fig. 3022.—Section of the Bony Cochlea, 1, Promontory; 2, lamina spiralis and ossa spiralaria; 3, fissura vestibuli; 4, lamina spiralis ossea; 5, recursus cochlearis of vestibule; 6, cupola; 7, hamulus; 8, canalis centralis; 9, canalis spiralis modioli; 10, modiolus; 11, scala vestibuli; 12, lamina spiralis ossea; 13, scala tympani; 14, tractus spiralis foraminosus; 15, internal auditory meatus. (Cunningham.)

modiolus is nearly horizontal, pointing from base to apex, outward and slightly downward and forward, the base of the cochlea being formed by the inner surface of the petrous bone. Contained within the cavity of the bony labyrinth, and on the whole parallel with its walls, is the *membranous labyrinth*, in which

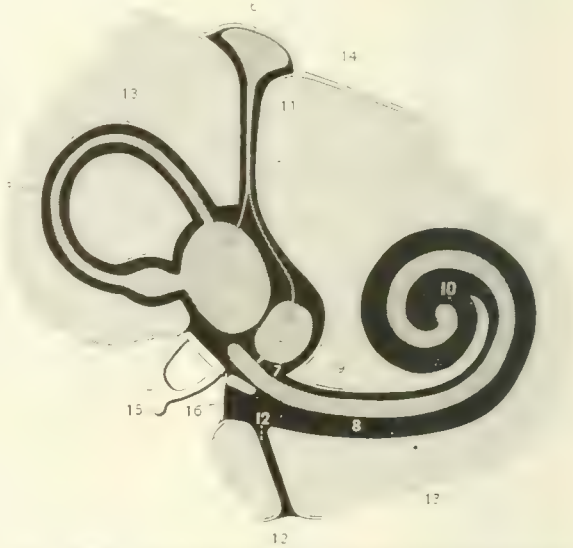

Fig. 3023.—Diagram Indicating the Peri- and Endo-lymphatic Spaces of the Inner Ear. (After Testut.) The endolymphatic spaces are represented in gray, the perilymphatic in black. 1, Utriculus; 2, sacculus; 3, semicircular canals; 4, cochlear canal; 5, endolymphatic canal, with its two initial branches; 6, endolymphatic cul-de-sac; 7, canal of Hensen or canalis reuniens; 8, scala tympani; 9, scala vestibuli; 10, their point of union at the helicotrema; 11, aquæductus vestibuli; 12, aquæductus cochleæ; 13, periosteum; 14, dura mater; 15, stapes in the fenestra ovalis; 16, fenestra rotunda and secondary tympanic membrane.

are found the essential structures of the organ of hearing (Figs. 3023–3025). The membranous labyrinth is filled with a somewhat watery, mucin-holding fluid, the *endolymph*, while a similar fluid, the *perilymph*, fills the space between the membranous labyrinth and the bony walls outside it. The perilymphatic space

is lined with lymphatic epithelium and is in communication, along the sheath of the auditory nerve, with the subdural and subarachnoid lymph areas of the brain. Numerous sheets and bars of connective tissue reach from the wall of the bony to that of the membranous labyrinth and help support the latter. That part of the membranous labyrinth which is contained within the bony vestibule is composed of two separate sacs which only indirectly communicate with each other (Figs. 3023, 3030). The posterior sac is larger and is known as the *utriculus* or *utricle*. From it spring the membranous semicircular canals. The smaller anterior sac is called the *sacculus* or *saccule*. The cavities of the utricle and saccule are indirectly continuous through two small tubes which arise from either sac and, uniting, form a single tube, the *ductus endolymphaticus*, which runs inward through a canal in the petrosal bone and ends blindly in a dilated, flattened extremity, the *saccus endolymphaticus*, which is supported between the layers of the *dura mater* within the cranial cavity. The plane separating the two vestibular sacs is perpendicular to, and opposite the fenestra ovalis (Fig. 3023). The sacculus communicates by a narrow tube, the *canalis reuniens*, with that division of the membranous labyrinth which is contained within the bony cochlea and known as the *canalis* or *ductus cochlearis* (Fig. 3023).

The eighth cranial or *auditory nerve* consists of at least two divisions having separate origins and different distributions. One of these branches passes finally to the cochlea, and the other to the vestibule and semicircular canals. The nerve approaches the labyrinth by way of a canal known as the *meatus auditorius internus*, and on reaching the angle between the base of the cochlea and the vestibule, the cochlear branch passes to its destination, while of the remainder of the nerve a superior division is distributed to the utricle and to the ampullæ of the anterior and horizontal semicircular canals, and the inferior division supplies the saccule and ampulla of the posterior canal. The cortical centers for sound perception are usually considered to be located in the anterior part of the first and second temporal convolutions, but their exact distribution is still in doubt.[8]

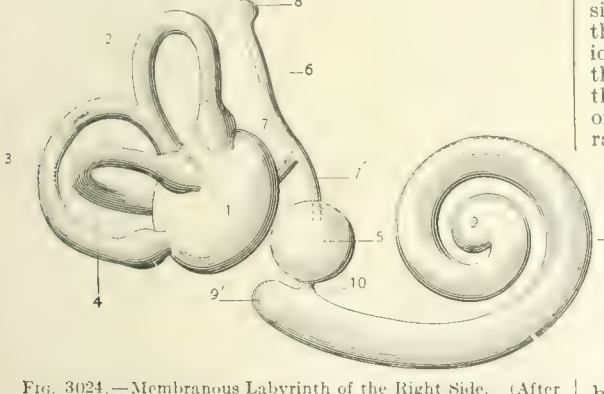

Fig. 3024.—Membranous Labyrinth of the Right Side. (After Testut.) 1, Utriculus; 2, superior semicircular canal; 3, posterior semicircular canal; 4, external semicircular canal; 5, sacculus; 6, endolymphatic canal, *ductus endolymphaticus*, with (7 and 7') its parent canals; 8, its terminal culdesac, *saccus endolymphaticus;* 9, cochlear canal, with (9') its vestibular culdesac and (9'') its terminal culdesac; 10, canalis reuniens of Hensen.

The internal ear or labyrinth presents the extraordinary example of a single sense organ being structurally divisible into two parts, each of which subserves a distinct physiological function. The membranous sacs within the vestibule together with the semicircular canals constitute the peripheral organ of what may be termed the "sense of equilibrium." This part of the labyrinth does not here concern us.

The special organ of hearing is contained within the cochlea. Fishes possess a well developed labyrinth which is devoid of the cochlea. Numerous experiments to determine whether fishes possess a sense of hearing have led to contradictory conclusions, but on the whole the evidence is negative. Although vibrations which usually excite audition may produce in them an active response, the same result is obtained after complete excision of the labyrinth; the reaction is probably due to some tactile feeling.

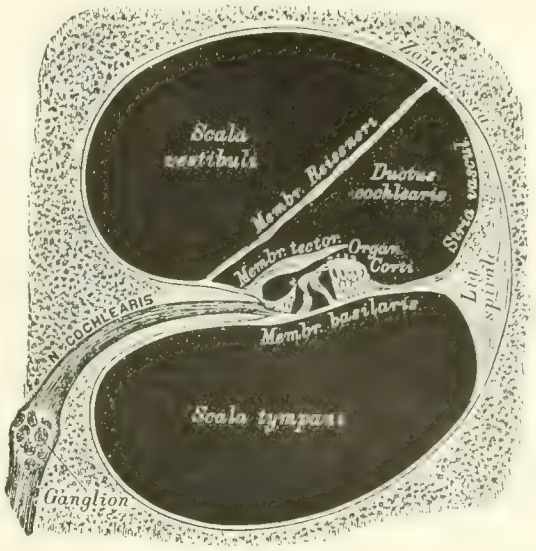

Fig. 3025.—Semidiagrammatic Section of a Cochlear Whorl. (After Heitzmann.)

The Membranous Cochlea.—By far the most complex structure of the ear is found in the cochlea. The membranous cochlea (Figs. 3025, 3026), sometimes known as the *canalis* or *ductus cochlearius*, is a tube of nearly triangular cross section. The base or outer side of this triangle is attached closely to the wall of the body cochlea; the upper side, supposing the modiolus to be vertical with its apex above, is made of a thin sheet of cells known as the *membrane of Reissner;* the lower side is made up partly of the bony margin of the *lamina spiralis* and partly of a membrane radially striated, stretched across from the edge of the spiral lamina to the side wall of the cochlea; this is called the *basilar membrane* or *membrana basilaris* (Fig. 3026).

The coiled tube of the osseous cochlea is thus divided longitudinally into three parallel tubes: the *scala vestibuli* and the *scala tympani* on either side of the lamina spiralis, and the *canalis cochlearis* between them, where the spiral lamina is wanting.

The *canalis cochlearis* contains endolymph and is closed at each end, but its cavity communicates by way of the narrow *canalis reuniens* with that of the saccule (Fig. 3024). The tubes or scalæ on either side of the membranous cochlea are perilymph spaces. The upper tube, when followed down to the base of the cochlea, is found to open freely into the cavity of the vestibule; hence its name of *scala vestibuli*. The lower tube ends blindly at the base of the cochlea, but, where this part bulges into the tympanum as the "promontory" of its inner wall, it is perforated by the aperture known as the *fenestra rotunda* whose proper membrane alone prevents the perilymph from escaping into the middle ear. This tube is therefore called the *scala tympani*. From its central position the membranous cochlear canal is sometimes known as the *scala media*.

As the spiral staircase formed by the osseous lamina spiralis and the membranous basilar membrane winds round the modiolus from the base to the apex or *cupola* of the cochlea, the radial width of the basilar membrane increases while that of the bony lamina decreases. In the basal whorl of the cochlea the width of the two is about equal, but near the cupola the lamina spiralis is nearly wanting. The radial width of the basilar membrane is said to vary from 0.495 millimeters at the top of the cochlea to about 0.041 millimeters near the bottom. (Hensen.) The scala vestibuli and the scala tympani have no communication except through a small aperture under the cupola of the cochlea known as the *helicotrema;* this is bounded by the hook-like termination, the *hamulus* (Fig. 3021), of the bony lamina spiralis, which forms the greater part of a ring completed by the pointed, blind extremity of the canalis cochlearis fastened above the hamulus to the cupola.

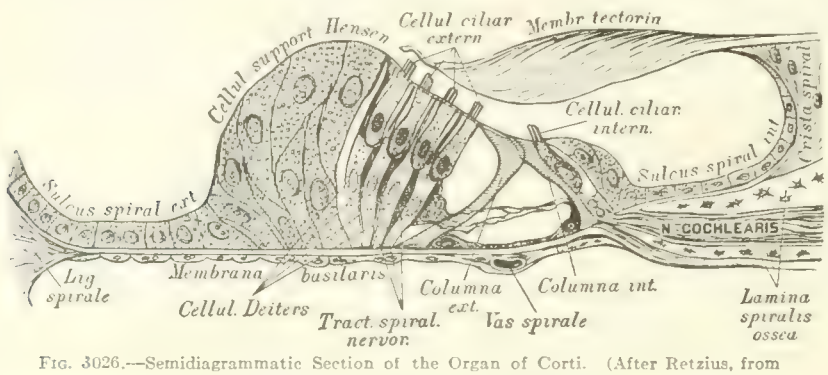

FIG. 3026.—Semidiagrammatic Section of the Organ of Corti. (After Retzius, from Heitzmann's "Anatomie des Menschen.")

Transmission of Vibrations through the Labyrinth.—We have seen above (p. 26) that composite air waves differ from the simple pendular vibrations of which they are made up by their form. That is, while in a simple pendular vibration the motion of an oscillating air particle is similar, and its acceleration or retardation is uniform on each side of the point of rest, in the composite wave this is not so. The tympanic membrane must respond to all the variations in the sound pulses entering the meatus and transmit them with exactness, though with diminished amplitude and increased force, to the foot of the stapes. The end of the long process of the incus rises somewhat in its inward excursion, so that the head of the stapes is slightly raised at each impulse. The motion of the stapes in the fenestra ovalis is, therefore, not so much that of a piston in a cylinder as a *wobble* about an axis that runs parallel and near to the lower edge of the footplate. (Henke, quoted by Hensen[5].) As the maximum excursion of the incus-stapes articulation is only about one-fourteenth millimeter, that of the foot of the stapes must be still further reduced and increased in power.

The fluid of the labyrinth being incompressible, any considerable inward movement of the stapes must be attended by provision for the outlet of the displaced fluid. Such a safety valve is found in the fenestra rotunda. Perilymph pressed away from the oval window may find a free vent by passing through the scala vestibuli toward the apex of the cochlea, through the helicotrema, backward by way of the scala tympani, at the basal end of which it finds the fenestra rotunda, and may cause its covering membrane to bulge into the tympanum. That such a transference of fluid in the direction from the oval to the round window can take place was demonstrated by Politzer, who inserted a glass tube in the fenestra rotunda and found that fluid in the tube took a higher level when strong air pressure was brought to bear on the outside of the tympanic membrane. It is hardly conceivable, however, that actual molar motion of perilymph through the helicotrema occurs with each oscillation of the foot of the stapes. The effect upon the membrane of the round window of a continuous musical note, for example, is probably to give it a fixed position midway between that resulting from the maximum and that resulting from the minimum displacement at the oval window. This action may be illustrated by a device sometimes used for the determination of the mean arterial blood pressure of an animal; the mercury manometer is constricted at one point to a narrow orifice which blocks the rapid oscillations of the heavy mercury, so that the difference in level of the fluid in the two limbs of the instrument is constant and represents the mean between the varying pressures. That the actual transfer of fluid from the scala vestibuli to the scala tympani is not necessary for the irritation of the nervous mechanism of the cochlea is indicated by audition through bone conduction, in which it seems that molecular vibrations may arouse the sense of sound by direct transmission through the osseous cochlea. We may look upon the action of the stapes as that of a hammer which applies sharp taps to the perilymph.

As the terminations of the auditory nerve are all within the closed and complex membranous labyrinth, vibrations of the perilymph, to have sensory effect, must be taken up by the wall of that structure. The sensory epithelium of the saccule, utricle, and semicircular canals would seem to be impressed by vibrations proceeding directly from the oval window. Considering the minuteness of the canalis reuniens, it is not probable that irritation of the cochlear nerve depends upon vibrations reaching them through the endolymph of the saccule, but that it is achieved through motion imparted by the broad way of the scala vestibuli, the diminishing caliber of which toward the apex of the cochlea would seem adapted to the concentration of energy of vibration toward that point. The indirect tubular communication between the various chambers of the membranous labyrinth and with the cranial cavity through the *ductus endolymphaticus* and its dilated extremity afford evident provision for the equalization of pressure throughout the endolymph.

The Membranous Cochlea and the Organ of Corti.—The *ductus cochlearis* is somewhat triangular in cross-section, its floor being composed, in the lower whorls of the cochlea, of the *basilar membrane* and the edge of the lamina spiralis (Fig. 3025); but the latter component decreases toward the apex of the cochlea so that both the relative and the absolute width of the basilar membrane increases as the cupola is approached. The delicate *membrane of Reissner,* stretched from a line on the lamina spiralis somewhat back from its edge to the wall of the bony cochlea, separates the canalis cochlearis from the scala vestibuli on the one hand, as the basilar membrane does from the scala tympani on the other.

From the physiological standpoint interest is chiefly centered in the basilar membrane and the structures supported by it. The *basilar membrane* is a sheet of complex tissue tightly stretched between the edge of the lamina spiralis and the outer wall of the cochlea. The membrane is fibrillated and splits readily in a radial direction, and has been supposed to repre-

sent essentially a series of stiff, elastic fibers more or less coherent in a cement substance (Fig. 3026). Seated on the inner part of the basilar membrane is the peculiar structure known as the *organ of Corti* (Figs. 3025, 3026).

The *organ of Corti* has as its supporting framework a series of modified cuticular epithelial cells known as the *rods of Corti* (*columnæ ext.* and *int.*, Fig. 3026), which are arranged along the inner edge of the membrane in two rows, an inner and an outer. The feet of Corti's rods are separated at some distance on the basilar membrane, but the rods are inclined toward each other and are united at the top, leaving between them and the basilar membrane the *tunnel of Corti*. The inner rods are more numerous than the outer, so that the latter are fastened rather between than to the ends of the former. Leaning against the inner or median side of the inner row of rods is a single row of *hair cells* (Fig. 3026), to which filaments of the auditory nerve are applied. On the inner face of these hair cells are several rows of columnar epithelial cells supported by a base of nuclei. External to the outer row of rods, and separated from it by a space, are four parallel rows of hair cells known as the *cells of Corti*. The hair cells do not rest upon the basilar membrane, but are upheld by four rows of specialized bodies, the *cells of Deiters*, inserted between and outside them and supported below by the basilar membrane. Outside these structures are several rows of columnar epithelial cells. The rods of Corti are peculiarly shaped at the top, the upper extremity of each being bent at an angle so as to project externally and parallel with the basilar membrane; these projections are the *phalangar processes* of the rods. These processes form the points of attachment, or the beginning, of the *reticulate membrane* (*membrana reticulata*), a peculiar network-like structure formed of cuticular rings and cross bars (not shown in the figure). The reticulate membrane stretches across the outer rows of hair cells, the body of each of which is enclosed by and is held at the top within a ring of the network. The inner or median face of each cell of Deiters is modified into a cuticular thread which is fused below to the basilar membrane and above to a ring of the reticulate membrane.

A sheet of radially fibrillated tissue is attached to the vestibular lip of the *limbus*, a promotory composed of connective tissue resting upon and fringing the edge of the *lamina spiralis*. This sheet is known as the *tectorial membrane* (*membrana tectoria*) and reaches out over the organ of Corti as far as the outermost row of hair cells (Fig. 3026). It is said, when in place, to lie in actual contact with the rods of Corti and the free ends of the hair cells, and it has been presumed to serve as a damper for the vibrations imparted to the organ of Corti. Howard Ayers[9] differs, in essential particulars, in his interpretation of some of the structures of the sensory organ of the cochlea from the current views which have been presented above. Thus Ayers asserts "that the so-called membrana tectoria is nothing more than the matted mass of hairs which spring from the tops of the hair cells and form a waving plume on the crest of the ridge of the organ of Corti."

He also holds the *membrana reticulata*, and several other structures described by different authors, to be nothing more than artifacts produced by the methods of preserving and manipulating the specimens.

Turning now to the connection of the sensory organ with the central nervous system, it is found that the cochlear division of the auditory nerve, together with the nutrient blood-vessels, penetrates the modiolus at its base and runs up through the spongy interior of the bony pillar (Fig. 3025). As the nerve ascends through the modiolus its fibers are gradually given off to run in a radial direction between the bony plates of the lamina spiralis. A collection of nerve cells forming the *ganglion spirale* is interposed in the course of the auditory fibers at the base of the spiral lamina. The fibrils produced by splitting up of the auditory nerve fibers are generally believed to terminate in clusters about the bodies of the hair cells.

Function of the Sensory Organ of the Cochlea and Its Mode of Action.—There is no doubt that the basilar membrane and the organ of Corti are devoted to translating the vibrations of physical sound into physiological nerve stimuli. It is the apparatus through which the period, phase, amplitude, and rate of motion of air particles are translated into auditory impulses which give rise to conceptions of harmony and discord. It is the musical organ of the ear. When we inquire into the way in which the cochlear instrument does its work, we are reduced to the use of hypotheses founded on the action of artificial instruments. All authors agree that the hair cells, round whose bodies are clustered the terminal filaments of the auditory nerve, form the ultimate sensory apparatus of the cochlea. But there are, in general, three different views as to the part played by the organ of Corti in the translation of endolymph vibrations into nerve impulses. The complexity of the organ of Corti in the ear irresistibly demands for it an important function in the acoustic process. But in singing birds, that must be supposed to have an "ear" for music, the organ of Corti is not developed. The radial fibrillation of the basilar membrane early suggested that it represented essentially a series of wires stretched side by side and capable, like those of a piano, of being thrown into sympathetic vibration by impulses reaching them from without. Calculation shows that the fibers are sufficient in number and vary enough in length to more than account for the known powers of the ear in its discrimination of pitch. The fibers of the basilar membrane are cemented laterally by a substance apparently little adapted to transmit vibrations. It may be supposed then, as Helmholtz first pointed out, that composite vibrations traversing the labyrinthine fluids are analyzed by the fibers of the basilar membrane into simple pendular vibrations, much as the notes of a singing voice may be analyzed by the wires of a piano when the appropriate dampers are raised. The theory assumes that, in some way, the movement of the radial fibers is transmitted to their appropriate hair cells and thence to the contiguous nerves. The various partial tones of a composite musical note would thus excite, with appropriate relative intensity, separate nerve fibers or groups of fibers, and the impulses reaching the brain would there be recombined into a specific psychic counterpart of the physical vibrations which entered the ear. This theory of Helmholtz, that the cochlea analyzes musical notes by sympathetic resonance, finds experimented support in work of Wittmaack[10], confirmed in essentials by Yoshii[11] and Siebenmann. It was found that guinea pigs, exposed for prolonged periods to continuous powerful sounds, developed circumscribed degenerations of the organ of Corti determined by the pitch of the sounds. The degenerations where localized in the basal, middle, or apical whorl of the cochlea according as the pitch of the sounds was high, medium, or low. It will be remembered that the fibers of the basilar membrane diminish in length, and increase in vibration rate, from the apex to the base of the cochlea.

W. Rutherford[12] and J. R. Ewald[13] have separately announced another view of the mode of reaction of the sensory organ of the cochlea to sound waves. They hold that the basilar membrane, like a telephone plate or a stretched sheet of rubber tissue, vibrates throughout with every force impinging upon it. The membrane when in action breaks up into nodes and segments determined by the composition of the exciting note, and from the complex of nerve impulses thus transmitted the brain builds up its sound perceptions.

Still a third view held by Shambaugh[11] and others, ascribes to the basilar membrane merely a supporting function and holds that the receptive vibratile apparatus of the cochlea is represented in the *membrana tectoria*. The fibers of the tectorial membrane rest directly upon the hair cells of the organ of Corti and it would seem easy for vibrations of the perilymph in the scala vestibuli to reach them through the thin membrane of Reissner's.

Such a view of the mode of stimulation of the hair cells of the cochlea is somewhat strengthened by the analogy of the utricle and saccule, the vestibular sacs concerned in equilibration. Here the sensory hair cells are capped by a mass of substance holding otoliths through which the cells doubtless directly receive their stimuli.

As mentioned above, Ayres goes much farther and regards the tectorial membrane not as an inert structure but as a living tissue composed of the more or less matted cilia of the hair cells which have usually been broken off close to their origin in preparing the specimen.

Comparison of Visual and Auditory Sensations.—No definite relation can be shown to exist between visual and auditory sensations as such, because they are different in quality. A man born blind may describe the blare of a trumpet as having the color scarlet, but such a statement is evidently only a metaphor expressing the relations of the psychical effect of the trumpet's note and the blind man's inference as to the associations suggested by the color. It is an interesting fact that the language of visual sensation is continually employed in illustrating peculiarities of sound, as in indicating the *quality* as the *color* of the note. In the same way other sensory impressions are used to illustrate visual description, as "warm" and "cold" colors. The intimate association of sound with color in certain persons is an interesting fact of psychology.

Both the auditory and the visual sensory cells are brought into functional activity by physical vibrations, in the one case of ether and in the other of labyrinthine fluid. That continuous sensation shall be aroused these vibrations must be repeated at a definite rate. We have found (p. 25) that the lowest rate which is recognized as sound represents a vibration rate of sixteen to twenty-four per second, while the highest note which is still audible varies in different individuals from 16,000 to 40,000 per second. In musical execution and in the ordinary uses of life the auditory range embraces about seven octaves, though the extreme range of hearing may be eleven octaves. It is said that there is a tonal zone of maximal sensitiveness extending from c^{i} to g^{iv}. The range of conversational pitch is included within two to three octaves, 80 to 640 vibrations per second. The average singing voice has a compass of about two octaves; the average speaking voice one of a few semi-tones. Visual impressions, as those from alternating black and white sections of a rotating disc, fuse together when the different sensations succeed one another at an interval varying from one-tenth to one-fiftieth of a second, the interval being shorter with stronger illumination. But the ear is able to distinguish apart vibrations recurring as "beats" at the rate of 132 per second. According to Geigel, two sounds can be distinguished when separated by an interval of only 0.006 to 0.007 second. The rate of succession of air waves falling upon the ear is marked in consciousness as a particular pitch. When separate luminous impressions, as those of a series of electric sparks, succeed one another with sufficient rapidity, the effect is that of a steady light; there is nothing analogous to musical pitch produced by increasing the rate of stimulation. Ether waves must represent a certain rate of vibration in order to excite visual sensation. The fastest vibration represented in the visible spectrum is less than twice the rate of the slowest; so that the range of vibration in the visual spectrum is included within a single octave. Difference of vibration rate, or of the factor usually considered the *wave length*, in ether, produces that peculiar variety of visual sensation known as color. The relative ability of the eye and the ear to distinguish the *wave form* of vibrations was the subject of a classic investigation by Helmholtz.[1]

The important visual phenomenon of fatigue finds its analogue in auditory sensation. For if a simple musical tone is sounded and immediately thereafter a composite note of which that tone is an upper partial, the note will be found to differ from its normal quality because it falls upon an ear disproportionately fatigued for one of its component tones. Each tone of the gamut fatigues the ear for itself but not for any other tone.[15] This fact is strong evidence in favor of the Helmholtz theory of selective resonance in the cochlea.

Judgments of Direction and Distance. Ventriloquism.—The direction and distance from which sounds come to the ear are not perceived directly, but our estimate of them is a judgment based on the loudness and quality of the sound sensation, combined with a power of reasoning from past experience. Thus, in seeking to discover the direction whence a sound comes, it is usual for an observer to turn the head to the position in which the sound is heard loudest, and thus to form an opinion as to its source. Errors of judgment as to direction are frequent, owing to the sound reflected from some object appearing louder than that coming in a direct line from its source. It is said that when there is total deafness in one ear, every sound seems to have its origin on the side of the healthy ear. Under experimental conditions Lord Rayleigh found no difficulty in distinguishing the direction of sounds coming from the side. With tones of high pitch the sound seemed louder in the ear nearer the source of the sound. With tones of low pitch the difference of vibration phase could be distinguished by the ears.[16]

When the eyes are closed and the head is unmoved, sounds produced anywhere in the median plane of the head are very imperfectly localized. There is a tendency to refer such sounds in a direction above and in front, no doubt because this is the space from which most sounds noticed come to us.

The quality as well as the loudness of a sound varies according to the distance of its source. Thus, the lower tones of a composite note die away earliest as a sound recedes, bringing the overtones into undue prominence. The art of the ventriloquist consists largely in altering the quality of the sounds he produces to imitate the quality they would naturally have if arising under the conditions which he would lead his hearers to believe to be their origin. A comparatively feeble sound near at hand may have the same quality as a very loud one heard at a distance; thus a frog croaking in an adjoining room of the laboratory was once mistaken by the writer for a large dog barking outside the building.

Acuteness of hearing differs greatly in normal individuals, and tests frequently show disparity in the sensitiveness of the two ears. The hearing ability of children is said to improve up to the age of twelve years. There is no functional relation between keenness of hearing and sensibility to pitch.[17]

Albino animals and also white cats and dogs with blue eyes are usually deaf. Rawitz[18] has found the cochlear sense organ degenerated in such cases.

It seems probable that congenital deafness, at least, is inheritable, and that Graham Bell's prediction as to the establishment of a race of deaf mutes from the intermarriage of such unfortunates may be verified.

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Hearing, Defective.—Disturbances of hearing may arise in the external, middle, or internal ear, or in all three simultaneously. For example a foreign body may enter the external auditory meatus giving rise to obstruction of incoming vibratory waves; it may ulcerate or perforate the membrane tympani and set up an acute middle-ear abscess; and finally it may cause infection of the labyrinth with temporary or complete loss of hearing. This is, to be sure, a rare occurrence, but such cases have been reported.

By far the commonest cause of bad hearing is some chronic disease of the tympanic cavity. Such a condition usually involves the drum membrane and the ossicles as well as the mucous-membrane lining of the cavity, and originates from a pathological condition in the postnasal space with extension into the Eustachian tube. In a second group of cases the disease begins primarily in the bony labyrinth capsule as a periostitis extending later to the deeper cancellous bone and finally involving the vital parts of the cochlea and the auditory nerve.

Cases in the first group are usually nasal or postnasal in their origin. In these patients the first process is an acute secretory middle-ear catarrh which is neglected by the patient and which induces a certain amount of middle-ear thickening to be increased by the next attack until the resulting deafness becomes perceptible to the patient and his friends. Of all disorders, adenoid in the nasopharynx unquestionably causes the greatest number of chronic middle-ear thickenings, many of which never receive treatment until the patient reaches adult life. All conditions causing nasal insufficiency, such as hypertrophied turbinates, septal deviations, etc., have an important bearing on aural disease.

Often the entire deafness can be definitely traced to a simple acute rhinitis in which the ear complication was at the time dismissed with the too common remark that "it would improve as the cold grew better."

Many of the acute infectious diseases, although more frequently causing acute suppurative processes, often start a chronic catarrhal middle-ear trouble. Especially where both ears are simultaneously affected—the one with an acute inflammatory process, the other with an acute catarrhal process—the pain of the former is apt to cause the patient completely to overlook the existence of the latter. When the catarrhal process occurs as a complication of influenza or of typhoid fever it is apt to be disregarded, while, on the other hand, a painful ear disease would, under these circumstances, be at once attended to.

A large number of middle-ear thickenings come from certain constitutional diseases, particularly rheumatism, gout, and syphilis.

Certain occupations are important factors: those in which the patient is exposed to draughts, dust, or other conditions tending to cause acute rhinitis; and those in which the ear is subjected to the jar of loud sounds, particulary boiler making, nail making, the shuttle rooms in mills, etc. Also the constant use of the telephone certainly plays the part of a cause in a number of cases.

The second group of cases, in which the disease process begins primarily in the neighborhood of the stapes base-plate, are rarely tubal in origin and not catarrhal in nature. The process is apparently a vasomotor one in many instances, often associated with neurasthenia. In many individuals it is clearly hereditary. In other cases syphilis, gout, osteomalacia, and other constitutional disorders seem to be at the bottom of the difficulty. After the local aural structures have undergone extensive pathological changes, treatment is of little avail. All cases of chronic progressive deafness have such alterations, and many of them represent types which might have been cured in their incipiency.

A frequent cause of deafness is found in the suppurative inflammation of the middle-ear (otitis media purulenta acuta et chronica) which has its origin in the pharynx or follows a purulent rhinitis. The coryza of the exanthemata very commonly has this termination. In view of the destructive character of the process, and considering the anatomical peculiarities of the middle ear and its relations, the gravity of this affection cannot well be overestimated. Its ravages are not always confined to the parts which are primarily involved, but may invade the mastoid antrum, or by secondary invasion give rise to caries, pyemia, cerebral abscess, and death.

It is thus seen that the ear affections which have their origin in inflammations of the nasopharyngeal mucous membrane constitute the vast majority of all diseases of the ear. This is of the greatest significance. Fortunately the invention of the pharyngoscope has turned the attention of otologists in this direction and much is to be hoped from early, accurate diagnosis and prompt treatment.

As would be naturally inferred, constitutional treatment becomes also a very important factor in the treatment of deafness of constitutional origin.

The interferences with the hearing that may exist in the external auditory canal are briefly best classified into mechanical obstructions, and those which arise from inflammatory action. Under the former class are to be placed foreign bodies, accumulations of cerumen, exostoses, and obstructive deformities; under the latter, the inflammatory diseases of the meatus.

Diseases of the internal ear are of primary or secondary inflammatory nature. Structural changes may be induced as a consequence of tympanic disorders, or they result from the effect of toxic diseases or arterial disturbances.

Deafness may be unilateral or bilateral. Circumstances of exposure or individual habit or accident determine the diseased process to one side or to both. This must be the explanation, as is claimed by some writers, if one ear is found to be affected more frequently than the other.

There is a reserve amount of hearing which can diminish so insidiously that the patient fails to perceive that he is getting deaf; therefore, many patients are first seen only when the ear condition has reached an advanced stage.

Functional Tests.—Functional testing of the ear is one of the most important parts of the aural examination. Unfortunately it has not always received the careful attention which it merits. It is only during the past four of five years that otologists have worked out and applied a series of satisfactory tests. During this time we have learned that the ear apparatus has a double function—a vestibular and a cochlear which are differentiated for quite varying reasons. The vestibular portion has to do with the orientation of

the body in space, and any disturbance of this apparatus causes symptoms of nasuea, vomiting, vertigo, and nystagmus which will be described more fully later. The cochlear portion, on the other hand, has to do so far as we know, only with hearing, and as this is the most important of the two functions, a thorough appreciation of the necessity of accurate tests must be kept in mind. We should remember that hearing takes place through air and through bone. Patients sometimes think they "hear" a tone when in reality they perceive it through a sense of touch by conduction through the bones.

Prof. Gustav Alexander of Vienna has devised a simple scheme which I find it convenient to follow both in office and in hospital practice. By the use of a rubber stamp all tests can be quickly and accurately recorded on the back of the patient's history card.

R	L	Air	Bone	
		V		Conversation Voice
		v		Whispered Voice
		P		Politzer's Acoumeter
		W		Weber
		S		Schwabach
		R		Rinne
		G6		Gell6
		Ga		Galton's Whistle
		h		Watch through Bone
		T		Long Speaking Tube
		St		Stenger's Test
		Sp. N		Spontaneous Nystagmus
		E		Equilibrium
		T. N		Turning Nystagmus
		Ca. N		Caloric Nystagmus
		G. N		Galvanic Nystagmus
Fistula Test		Co. N		Compression Nystagmus
		A. N		Aspiration Nystagmus

Schema for Aural Tests. (Modified from Alexander.)

In estimating the degree of hearing, we should use at least three separate tests—noise, and high and low musical sounds. These we possess in the acoumeter, speech, and whisper.

Conversation Voice (*V*).—If we test the hearing by spoken words, we must remember that not only should the person hear the word, but he also must understand and be able to repeat it after us. Therefore, this method is not adaptable to children under ten years of age as a rule. Also in nervous patients the personal equation is very difficult to overcome. Normal hearing distance for ordinary conversation speech in the open air is about 60 meters (195 feet); in a closed room from 40 to 50 meters (130 to 162½ ft.); for accentuated whispers 25 to 30 (81 to 97½ ft.), for typical whisper from 20 to 25 (65 to 81 ft.). These figures apply only to normal hearing. All normal persons possess a greater amount of hearing than is necessary for ordinary conversation uses.

Each ear should be examined separately; the other being shut out. It is important also that the patient keep the eyes closed or be blindfolded in order that he does not watch the lips and guess what is being said. Words should be used which are understood by the patient; words that are common to ordinary speech such as chair, window, door, table, man, boy, etc. When *whispered speech* (*v*) is used, only the residual air left in the lungs after exhalation should be used. Special regard should be given to hissing sibilants, the high-pitched soft G, F, the explosives, and the letter R. Hissing sounds (S, Sh) are usually heard worst in diseases of the sound conducting apparatus, F in labyrinthine disease, and R in defects of the tympanic membrane (Yearsley).

The Acoumeter (*P*).—Politzer's acoumeter is a little instrument in which the striking of a movable steel rod upon another which is fixed gives a sharp uniform click, heard normally fifteen meters (about 16 yards). It is a very simple means for measuring the hearing power for noises. It possesses very little value in the estimation of air conduction since the noise of the acoumeter can no longer be perceived in very advanced diseases of the inner ear.

Fig. 3027.—The Acoumeter.

Tuning Fork Tests.—An important factor in functional testing is examining for the perception of tones. The tuning fork is the best instrument for this purpose. It must be sufficiently large; that is, the tine must be at least eight centimeters long, and it should be made from one piece. The nickeled tuning forks are not to be recommended, since the nickeling diminishes the duration of the vibration. The fork should also be free from overtones and should have the longest possible swinging duration so that we may compare the duration of perception found in the diseased ear with that of the normal ear. If the fork dies out too quickly then we do not have time enough

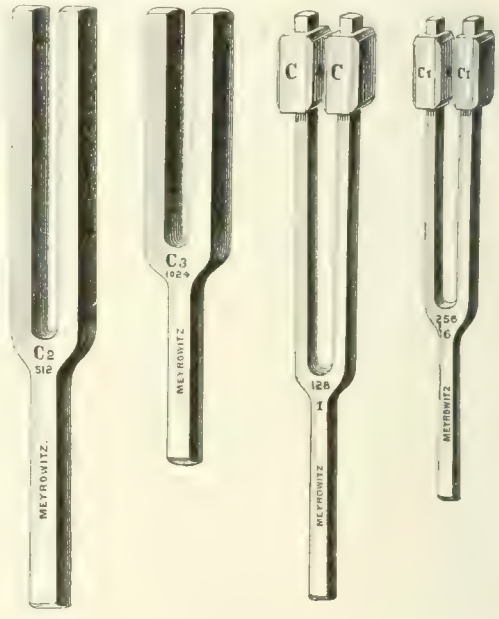

Fig. 3028.—Hartmann's Set of Tuning Forks. The largest fork (C_4) is not shown here.

to test the difference. The human ear is capacle of perceiving from 12,000 to 40,000 double vibrations per second. For clinical purposes the lower limit of the tuning fork is about sixteen vibrations and the upper C-5 about 4,224 vibrations.

Very satisfactory forks for the application of most tests is the set of Hartmann. This consists of five tuning forks.

C 128 vibrations per second for the pure tone.
C′ 256 vibrations per second for the pure tone.
C″ 512 vibrations per second for the pure tone.
C‴ 1,024 vibrations per second for the pure tone.
C⁗ 2,048 vibrations per second for the pure tone.

This set is used by Schwabach in his test. An

accurate diagnosis may be made by using the following instruments, a low pitched fork, C-1 to determine the low-tone limit (or errors of the conducting apparatus); a higher-pitched fork, as C″, for determining the Schwabach, Weber, and Rinné tests (absolute bone conduction); and the Galton whistle, for determining the upper-tone limits or disturbances of hearing due to disease of the receptive apparatus. The tuning fork should be struck on a moderately soft substance (*e.g.* wood, covered with leather), in order to avoid the formation of over-tones. The clamps shown on the C and C′ forks are used in order to prevent these.

At the Urbantschitsch Clinic in Vienna, not more than three forks are ordinarily used. A low fork corresponding to that devised by Dench having about sixty-four double vibrations per second, a high fork corresponding to the C–4 of Hartmann's set, and a medium fork known as the Vienna Model. All tests are performed by excluding the opposite ear with Bàràny's noise apparatus.

Weber's Test (*W*).—Weber's test is one of the oldest and commonest in use. It depends upon the fact that a vibrating fork when placed upon the vertex of the skull will be heard by both ears equally well if the ears are normal (Weber in the head). If now one ear be stopped with the finger, the fork is heard more distinctly in the obstructed ear. This is due to the fact that normally the sound transmitted through the skull to the inner ear is in part reflected outward and escapes by way of the external auditory meatus; therefore, any interference such as a foreign body in the meatus, or disease of the tympanic cavity which limits this escape of vibrations intensifies the amount of stimulus in the concerned ear.

In inner ear disease where there is no preception of tone, the tuning fork is referred to the sound ear or less diseased side.

Schwabach's Test (*S*).—The vibrating tuning fork is held in the middle of the forehead, or against the mastoid and the investigated person must say whether the tone is heard or not. In order to prevent fatigue or to do away with suggestion, the fork is removed from time to time for a second. One can then tell whether the patient hears or feels the fork. By comparing the duration of hearing of the investigated person with the examiner's own duration, supposing this to be normal, one can tell whether the bone conduction is normal, lengthened or shortened. In diseases of the sound conducting apparatus, Schwabach is lengthened; in diseases of the inner ear, Schwabach is shortened. The degree of shortening corresponds for the most part to the degree of hearing defect. However, the degree of lengthening in many cases does not correspond to the severity of the disease. In general, cases of acute middle ear disease show Schwabach more lengthened than in chronic cases. If in disease of one middle ear the bone conduction on this side is lengthened, then the tuning fork placed in the middle of the forehead shows lengthened bone conduction; if there is unilateral disease of the inner ear, the tuning fork thus placed shows shortened bone conduction. Many authorities make the Schwabach test not from the forehead, but from both mastoid processes, under the assumption that the duration found in the mastoid gives a better idea of bone conduction. If we find Schwabach's test not normal we are safe in the assumption that an ear disease is present. This is true, even if the other functional tests, especially the determination of hearing distance, seem to show no aural disease. Schwabach's is therefore a very valuable sign.

Rinné's Test (*R*).—Rinné's test is simply a comparison of air and bone conduction of the same side. Usually the duration of the tone preception through air is about twice as long as through bone. Rinné is therefore positive when this relation exists; negative, if bone conduction is longer than air conduction. Varying corollaries may be derived from this test. With normal hearing Rinné is positive with normal duration of perception through bone and air. In disease of the sound-conducting apparatus, Rinné is negative with shortened air and lengthened bone conduction. In diseases of the sound-perceiving apparatus, Rinné is positive with shortened bone and shortened air conduction. In combined disease of the sound-conducting and sound-perceiving apparatus, Rinné is negative with shortened bone conduction.

Lake of London has worked out some very interesting and useful conclusions with Rinné's test. From his work the following postulates may be set down:

Group I. Rinné positive.—1. The bone conduction is normal and the air conduction is greater than the bone conduction by thirty-five seconds. (This is the normal reaction of the healthy ear.)

2. The bone conduction is normal, the air conduction is reduced by a number of seconds less than thirty-five.

3. The bone conduction is increased by a number of seconds less than thirty-five, the air conduction then being equal to thirty-five seconds minus the number of seconds by which the bone conduction is increased.

4. The bone conduction is decreased by a number of seconds less than thirty-five, the air conduction decreased by a number of seconds less than thirty-five plus the mastoid decrease.

Group II. Rinné negative.—5 The bone conduction is normal, the air conduction is decreased thirty-five or more seconds.

6. The bone conduction is increased, the air conduction is decreased thirty-five or more seconds.

7. The bone conduction is decreased, the air conduction decreased thirty-five seconds plus the number of seconds by which the bone conduction is decreased.

Increase of bone conduction usually means disease of the sound-conducting apparatus; it is generally present also in the early stages of otosclerosis. It may also indicate hyperesthesia of the auditory nerve. When air conduction is diminished, and bone conduction is normal or increased, it is the middle ear alone which is diseased.

Decrease of bone conduction to a slight extent is found in most cases of conductive defect when the latter has been present some time. In such cases it is not usually more than ten seconds at the most. Consequently, any loss of bone conduction over ten seconds should be taken as indicative of involvement of the perceptive apparatus, either functional or organic, especially when air conduction remains fairly good.

In far advanced ear diseases, Rinné is usually negative whether there is disease of the sound-perceiving or of the sound-conducting apparatus or both. In advanced progressive deafness, air conduction always diminishes more rapidly than bone conduction. In cases of *slight* disease of the sound-conducting apparatus in which there is lengthening of the bone conduction, and slight shortening of air conduction, the same duration of time results for both air and bone conduction. In many cases of advanced disease in the inner ear, Rinné's test is a diagnostic aid.

Gellé's Test.—This is a test for determining the movability of the stapes. It is best carried out by means of a C′ fork, a piece of rubber tubing and a Politzer ear bag. In a normal ear, if compression is made in the auditory canal, sounds are indistinctly heard. This is due to a compression of the stapes in the oval window, and to inhibition of the stimuli affecting the labyrinthine fluid and terminal nerve cells. If a Politzer ear bag attached to this rubber tube be compressed and a vibrating tuning fork be placed thereon, the sound is indistinctly heard. That is, during compression the patient hears worse. If a vibrating tuning fork be applied to the Politzer ear bag, the patient hears the tuning fork very distinctly when no pressure is made. This holds good

where there is free movement in the ossicular chain. If, however, the stapes be immovable, compression or aspiration in the external auditory canal will make no difference in the patient's hearing.

Gellé's test gives us a trustworthy idea of the condition of the labyrinth windows. A negative result is of especial significance in the diagnosis of otosclerosis. It is one of the first signs which can be elicited in this disease, and is therefore important as an early diagnostic aid. In cases of chronic middle ear thickening we are frequently able only through Gellé's test to determine the condition of the labyrinth windows; that is, whether a scar or other pathological tissue has formed about the oval or round windows.

Qualitative Hearing Test.—In disease of the sound-conducting apparatus C-1 is negative or markedly shortened; C-4 is normal. In disease of the sound-perceiving apparatus and especially in the region of the basal portion of the cochlea which represents the place of perception for high tones, there is a normal duration of perception for the C-1 tuning fork and shortening for the C-4. We are thus able to diagnose the kind of hearing difficulty by this simple test. The first sign that a middle ear disease has attacked the labyrinth is given by the significant shortening of the perception of the C-4 fork by air conduction. Such a fork has a duration from fifty-four to sixty seconds. The most accurate scientific tuning fork tests are those carried out by continuous series of forks known as the Bezold-Edelmann. The ten forks used give a series from C-2 to a-2. For the high tones above a-2, three whistles are used. The tone of the large whistles reaches from a-2 to a-3. That of the small whistle from a-3 to a-4.

Galton's Test (*Ga*).—For tones above a-4 Galton's whistle is used. This apparatus consists of a steel tube of a given size in which air is caused to vibrate by means of a rubber ball fitted to one extremity, while the length of the tube may be regulated by turning the milled head at the other end. The note produced by it will become higher and higher as its length is diminished. In other words, the Galton whistle acts as a closed organ pipe in which the column of air is set in vibration and the length of which may be varied at will.

Fig. 3029.—Galton Whistle.

Recently the monochord of Struycken has been recommended for accurate determination of the upper tone limits.

The tone variator of Stern allows an almost imperceptible change from one tone to another. From a clinical standpoint, this instrument is, however, impossible since it is large, cumbrous, not transportable and very expensive.

Urbantschitsch's harmonica is of value in determination of remains of hearing in cases of severe deafness and for the examination of the deaf and dumb. The trying out of the continual tone series in all ear diseases is practically impossible because it requires from one to two hours; therefore we use it only in those cases in which the usual quality test is insufficient. For example, in cases of traumatic injury to the labyrinth where litigation is likely.

Politzer's Test.—This is a test for the patency of the Eustachian tube. The investigated person holds a little water in the mouth. If the tube is normal, a vibrating tuning fork held in front of the nose is better perceived by the patient during the act of swallowing. In diseases of both Eustachian tubes there is no increased hearing on swallowing. In unilateral disease, at the moment of swallowing the fork is heard better in the good ear; that is, on the side in which the tube is open during the swallowing act. The test is especially valuable in cases where it is impossible to determine the condition of the tubes in any other way.

The Watch (Schwabach).—The average watch can be heard through bone in any part of the skull up to the fortieth year, and over the mastoid process up to the fiftieth year in normal persons (Alexander). An increased perception of the watch tick through the head bones signifies some disease of the sound-perceiving apparatus. Negative perception of the watch through bone can only be of value in the diagnosis of disease of the sound-perceiving apparatus when other signs of disease of the inner ear are also present. In exceptional cases in young people who have complete normal hearing, the watch may not be heard through the bone. Neurasthenic ear patients sometimes think they hear the watch tick but testing with a stop watch shows, us immediately the true condition.

The use of the watch for the testing of hearing distance through air is of no practical value. Every watch varies in its tick, not only from other watches, but in itself as well, according as it is affected by the weather or recent winding. It varies in both pitch and volume. This alone is sufficient to render it a fallacious test. There is, however, another and more cogent reason for its unsuitability for the otologist's purpose—the tick of a watch is a combination of two distinct factors, noise and musical sound. Moreover, in the watch, the musical sounds may be both high and low. Therefore any patient may hear one part of the tick without the other, according as his hearing is diminished for high or low tones or noise. It needs no elaborate description to see at once what fallacies may arise from the use of the watch as a test for air conduction.

Long Tube Test (*T*).—This is useful chiefly because we can test one ear at a time for the perception of conversation or whispered voice. A rubber tube is used similar to that recommended by Currier of the N. Y. Institution for the Instruction of the Deaf and Dumb. This tube should be about four meters long by 1.5 centimeters in diameter, and should be provided with a metal ear insert, and a hard rubber transmitter.

Sometimes in a case of undoubted unilateral complete deafness, we are surprised to find that the deaf ear has an apparent hearing distance from one to two meters for conversation speech. From this we may derive a helpful rule: When we find a patient supposedly deaf in one ear who has an apparent hearing distance of two meters conversation voice or thereabout, we must test this ear accurately to find out whether this hearing distance is actual or whether there is only an apparent hearing distance determined by the opposite ear. If the words spoken into the tube are repeated promptly without mistake, then obviously, the tested ear is capable of hearing speech. If only occasional words are understood and correctly repeated, or if no word at all can be repeated, then we may make the diagnosis of deafness for speech.

Stenger's Test (*ST*).—This is also a test for unilateral deafness. It is of especial value in cases of malingering, and is widely used in Germany and Austria to try out soldiers who are attempting to shirk duty because of alleged deafness.

Two identical forks are necessary. The small a-1 is the best fork to use. The test depends upon the principle that when both ears are fairly normal a vibrating fork held near the tested ear will no longer be heard when the vibrating companion fork approaches the other ear. In order to prevent errors and confusion, it is important that the investigator always stand behind the patient. It is also important that the investigated person does not know

that we use two identical forks for this test. The patient has only to state whether he hears the tone on the right or the left.

Let us suppose that the patient claims that he is deaf in the right ear. We stand behind him and set both forks vibrating by an equal stroke. One fork is now held near the left (good) ear, and he of course, hears it. We then bring the companion fork nearer and nearer to his right ear, and ask him if he still hears a vibration in his left ear. He will answer "no" if the right ear is intact, and "yes" if the right ear is very deaf. This is a very valuable and reliable test. The two forks are identical if, when one fork is set in vibration and held in apposition to the resting fork, this resting fork can then be set into "sympathetic" vibration.

A very excellent test for the determination of unilateral deafness is the

Reading Test.—This I first saw demonstrated by Ruttin in Vienna. It is well known that if a normal person is asked to read and both ears are stopped so as to exclude sound, the person will involuntarily raise his voice until it becomes almost a shout. Now if a person claim absolute deafness in the right ear, for instance, and some contrivance like the noise apparatus of Bárány be sounded in the left ear, he will raise his voice while reading to a marked degree. If on the other hand the right ear be normal or nearly so, there will be no appreciable change in the pitch or quality of the voice.

Dozent Bárány of Vienna, also Neumann, and later Voss have invented a special clock-like affair which, when introduced into an ear, is capable of absolutely shutting out all external sounds. This is of special value in testing for labyrinthine disease in that one

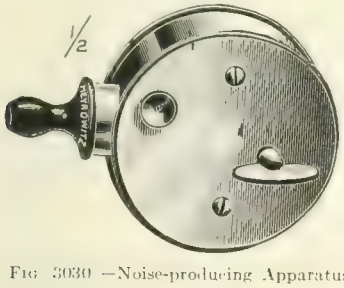

Fig. 3030.—Noise-producing Apparatus.

ear can be absolutely excluded. Dr. Francis White of New York, instead of the noise apparatus, uses a Paquelin cautery bulb and tube for this purpose. He found that the continuous noise of the air rushing from the tube against the ear drum was quite as efficient as the buzzing noise caused by the sound apparatus. It seems to be thoroughly efficient and is quite inexpensive.

The following general rules are useful as a rough guide in the diagnosis between obstructive and perceptive deafness: (1) There is a loss of air conduction and Rinné's reaction is negative. (2) High-pitched sounds are heard better than those of low-pitch. (3) Hearing is better in a noise. (4) The acoumeter is heard better than spoken speech.

Perceptive deafness may be suspected when: (1) Bone conduction is diminished by more than ten seconds. (2) High-pitched sounds are heard badly. (3) Hearing is worse in a noise. (4) Spoken voice is heard better than the acoumeter.

Mechanical Aids to Hearing.—The first account of a device worn within the ear for the purpose of improving the hearing was described by Dr. Yearsley, of London, in 1848. He was informed by a patient from the United States who consulted him, that, by placing a rolled strip of paper in the auditory canal, the hearing was markedly improved. Tests made at the time proved the statement to be true beyond question. Dr. Yearsley was quick to take advantage of the discovery, and subsequent experimentation led him to substitute pellets of cotton for the twisted paper, since frequent trials of the latter had invariably failed on other patients.

Since that time no end of curious contrivances have been invented for the improvement of hearing. Many if not most of these have been practically worthless, and of those from which benefit might be derived, many are so cumbrous and unwieldy as to preclude their use. A visible artificial aid to hearing is always a matter of comment, and since most deaf

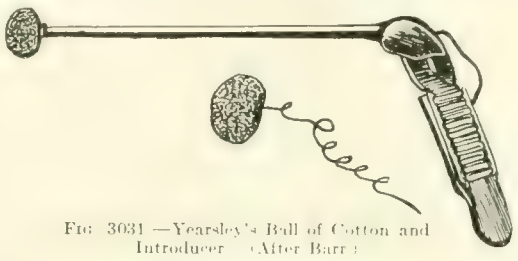

Fig. 3031.—Yearsley's Ball of Cotton and Introducer. (After Barr.)

persons are very sensitive, the wearing of such an aid is extremely objectionable. When we become as accustomed to hearing accessories as we are to glasses for the eyes this prejudice will be overcome, and doubtless an efficient instrument may yet be made which, with adjustment, will be of help to many patients.

The ideal instrument, did it but sufficiently contribute to the augmentation of the sound waves, would be one limited in size to the diameter of the meatus and auditory canal, and which could be worn unobserved. But, unfortunately, such devices aid only by affording support to the remnant of drum membrane which may be present, or to the ossicles, and by directing or concentrating upon the sound perceiving apparatus such aerial vibrations as are collected by the auricle for transmission into the meatus. Could a small instrument be devised that would render the same service as one of the larger kind, the ideal would be reached. The problem has not yet been solved and will not be easily.

Before advising the use of a mechanical aid to hearing it is very necessary to make a careful diagnosis. One must know the condition of the tympanic membrane; whether intact, partially destroyed, or totally destroyed. No great help can be expected from the use of an artificial drum if the normal drum is intact. If the drum is partially destroyed, mere closure of the perforation may improve the hearing; likewise if total destruction of the drum has taken place any foreign substance, such as a piece of cotton, if properly prepared, may improve the hearing when applied to the inner tympanic wall. The condition of the middle ear must be exactly understood, and one must know the condition of the round window, whether the ossicles are fixed, especially the stapes, whether the ear is dry or full of discharge, and whether scars and adhesions are present. The same careful diagnosis must be made of the condition of the internal ear, for if there is degeneration or destruction of the auditory nerve very little can be expected from any mechanical aid. In general it may be said that any aid which is introduced into the auditory canal, such as a hard rubber or metallic substance, is likely to do more harm than good. There may be temporary improvement, but this does not continue long; moreover, the presence of such a substance sets up irritation and, perhaps, also ulceration with annoying complications therefrom.

In all artificial drums the chief end to be obtained is direct sound transmission through the inner wall of the tympanic cavity by way of the stapes, the

round window, or the promontory. If loss of air vibrations is caused by a perforation of the tympanic membrane, an effort should be made to close such perforation. The edges should be freshened by caustic applications and a piece of thin (cigarette) paper or very fine rubber dam should be carefully applied to cover the hole. This is usually possible when the middle ear is dry, but any moisture will loosen the edges of the splint and defeat healing. In one of my cases, a patient of Prof. Gruber of Germany, who had a large dry perforation in the region of the attic and antrum, the hearing was about doubled by the use of the Yearsley ball thoroughly moistened with fluid albolene.

As to the deafness in cases of total destruction of the drum membrane, Bárány has a theory that its severity is due frequently not to fixation of the stapes or structural closure of the round window, but to the fact that sound waves entering the auditory canal strike simultaneously upon both the foot plate of the stapes and the membrane of the round window and that, therefore, the membrane of the round window is prevented from compensating for the movements of the stapes.

Dench of New York has a very simple method of dealing with such cases. He takes an ordinary cotton applicator and winds it with cotton allowing the cotton to project beyond the end of the applicator. It should be rolled firmly on the applicator, and patted down over the tip, like a mushroom; it is then slipped from the applicator and part of the long shank is cut off leaving perhaps an eighth of an inch projecting so that the patient can readily remove it. The cotton is now moistened in sterile albolene, then laid on a sterile gauze towel, which takes up the excess of albolene. The pledget is then grasped with a pair of forceps and introduced into the ear, care being taken to place it directly over the head of the stapes. It usually has to be shifted from side to side and up and down until it is as nearly over the head of the stapes of the oval window as one can get it. By guiding it with a fine applicator one can find the position in which the patient will hear the best. At first several trials must be made, but eventually the patient will tell where to place it. In fact, some patients can place the pledget better than the surgeon himself.

Duel has improved upon this by dipping and smoothing the cotton in collodion. After it has become dry it can be introduced into the ear.

Fig. 3032.—Toynbee's Artificial Drum Membrane.

In cases where the perforation is small Dench makes use of a piece of moderately thin paper, such as a foreign bond paper which is very thin and very tough. A circular disc is cut out and sterilized in alcohol and bichloride of mercury (1–3,000) and then laid over the perforation. The result in some cases is quite remarkable.

Patients become more proficient in introducing the artificial drum than the doctor himself, for they are able to tell when the pledget is in the proper place. They must be taught to observe surgical cleanliness. They must make sure that the cotton is sterile, that the albolene with which the cotton pledget is moistened is sterile, and that the hands are throughly washed before moulding the pledget. If these points are attended to trouble is unlikely.

Modifications of the original artificial drum membrane of Toynbee are numerous. As sold in the shops of to-day, it consists of a thin circular disc of india-rubber tissue, to the center of which is attached a gold wire.

Politzer invented for use among the poor an artificial membrana tympani, the manufacture of which is, as he states, very simple. A piece is cut from the side of an india-rubber tube two to three millimeters thick, and to the lower end of this is fixed a strong piece of wire.

There are two types of sound transmitting instruments; tubes or sound receivers and the resonators or trumpets. In the trumpets and horns the idea is to collect the sound waves and throw them into the ear in parallel waves. The curve of the collector or resonator—the reflector—must be more or less parabolic so as to give the maximum amount of sound at the entrance of the tube.

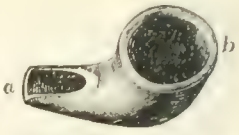

Fig. 3033.—Politzer's Metallic Horn, to be Worn as an Aid to Defective Hearing. *a*, End which is to be introduced into the orifice of the external auditory canal; *b*, larger flaring end which is to be directed toward the hollow of the concha.

The ordinary speaking tube carries sound very distinctly and conversation can be heard for 1,200 feet with absolute distinctness; but our hearing is so much worse in air, owing to the loss of the vibrations in the surrounding ether, that only a small number of vibrations come into the ear. If we can retain a large number of these vibrations, there will be an increase in the hearing power owing to increased stimuli.

Politzer has devised an instrument the shape of a hunting horn and about an inch in length. The narrow end is introduced into the meatus and the mouth directed to the hollow of the concha. The object of this instrument is to increase the normal effect of the inner surface of the tragus in reflecting the waves of sound coming from the concha into the external canal. Politzer noted improvement in three-fourths of his cases from use of this instrument. Other surgeons have not met with the same degree of success.

Fig. 3034.—Currier's Conico-Cylindrical Tube.

For short distance work only, the best instrument is probably Currier's *conico-cylindrical tube* (Fig. 3034).

This instrument which is often termed a "conversation tube" consists of a tube three and one-half feet long, which has a bone or hard rubber tip at one end, while the other end is a bell shaped mouthpiece made of the same material. The tip and mouthpiece are connected by an elastic spiral wire tube covered with rubber and over-spun with either silk or mohair. The tube is conical, thus forming a gradually decreasing channel from the mouthpiece to the ear. The lips should be placed close to the mouthpiece, and the speaker should at first modulate his voice, as loud tones are often very distressing to the listener. It may be worn around the neck, under the coat or cloak, or rolled up and carried in the pocket.

The *London hearing dome* of which the so-called "grand opera dome" is a simple variation, is an inexpensive instrument and in cases of deafness of the less severe type is

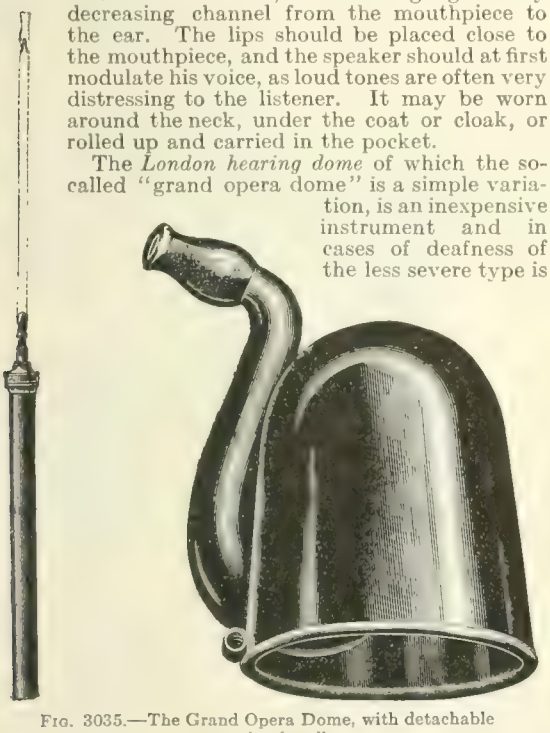

Fig. 3035.—The Grand Opera Dome, with detachable extension handle.

not infrequently of help to the user. It is said to be made of metal such as is used in the manufacture of musical instruments on account of the superior resonating qualities. These domes are also made with perforations at both ends so that sounds may be conveyed to the ear from the back as well as from the front. The opera dome is made of hammered bell brass, all its parts brazed together and covered both in and outside with a jet black material, thoroughly baked on, which will not wear off or crack. It is also supplied with a detachable extension handle five and one-half inches long when closed, ten inches long when extended.

Fig. 3036.—The Akou Concentrator.

The *Akou concentrator* has been designed to magnify as well as to concentrate sound waves. These enter the base of the resonating chamber and converge through the narrow neck, causing a rebounding of the waves outward around the dome of the instrument to the nodal point at the top. Just below the apex begins a funnel-shaped tube which goes part way down and out with an upward curve, terminating in an ear tip that fits snugly in the ear. This tube gets gradually smaller to the point. The concentrated sound waves are thus impelled forward and enter the ear in their strongest power. It is made of bell metal, and measures two and one-half inches in width and five and one-half inches in height. It is a very clear-toned instrument for distance hearing.

The *Hearwell churchphone* is a type of trumpet or horn and is partially collapsible. According to the

Fig. 3037.—The Hearwell Churchphone.

manufacturers it is one of the strongest distance-hearing instruments. It is made of moulded hard rubber and for a large instrument is very graceful in form. It has a nicely polished outside surface. The dotted lines show how it can be telescoped to a smaller

Fig. 3038.—The Audiat.

size for carrying, and it also can be adjusted for either ear. The diameter of the receiving end is three and three-fourth inches. The shape is such that it can be held close to the body, and all that is in sight is the small tube going into the ear. For church or concert use it is for certain persons a satisfactory aid.

The *Audiat* is an improvement in shape over the tin trumpet, and is more easily carried. The sound-receiving end is a flat oval five inches in diameter by one and one-fourth inches thick. Its peculiar shape is well adapted to gather in sounds and convey them strongly to the ear. It is one of the best arrangements for public speaking or conversation, and is of special use to the aged and infirm, as it can be held to the ear without using the hands. It is made of japanned black tin, or horn, and by means of the joint in the center can easily be adjusted for either ear and taken apart for carrying about.

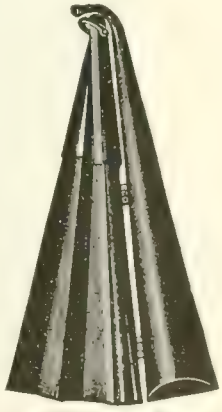

Fig. 3039.—The Folding Fan Trumpet.

The *Folding fan* instrument consists of quite a powerful hearing horn attached to a black folding fan. The trumpet extends the length of the fan and is hinged to the outside strip. By this means it is

entirely concealed when the fan is in use, and in hearing with it the patient appears to be resting the head on a fan. By opening the folds a little, the hearing device can be completely concealed. It is quite powerful and suitable for hearing in church, lectures, or for general conversation.

Fig. 3040.—The Lorgnette Hearing Horn.

The *Lorgnette hearing horn* is not very powerful but is inconspicuous and of some value in cases of partial deafness. One can use plain glass in the spectacle frame, or have it fitted with the proper lenses. It is made of imitation tortoise shell, neatly finished without any angles to catch fast in the clothing, and weighs only one and one-half ounces.

The *Sonor* is a French invention and for its size and simplicity is one of the best of the horn devices. It is a very good imitation of a lady's purse, is inconspicuous, and has considerable acoustic value. When in use the ear piece is pulled out and inserted in the ear. Only close scrutiny discloses that the purse-like article held carelessly against the face is used to aid the hearing. When closed it readily passes inspection as a neat and attractive ornament to carry in the hand. The bottom is artistically fenestrated and fashioned to catch sound.

The *Otophone* was invented by Dr. J. A. Maloney of Washington, D. C. It is so constructed that the column of air does not strike directly against the drum head but is intercepted by means of a diaphragm resembling that used in a telephone receiver. There

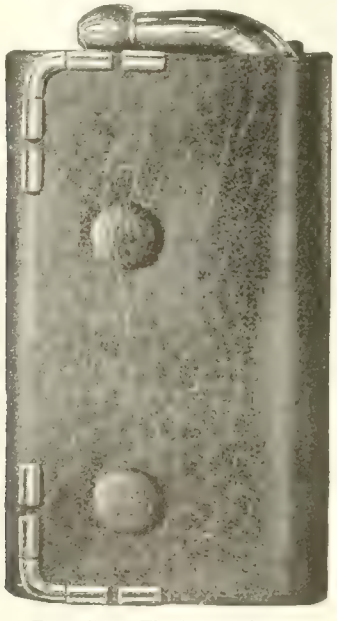

Fig. 3041.—The Sonor (closed).

are, of course, no adventitious sounds, and only proper voice tones are transmitted. It magnifies the sound considerably and gives it clearness and definition. It is placed against the ear and not inserted, thus preventing all possible irritation or damage to the meatus, such as furuncles, etc. The tube form of this instrument is especially designed for close conversation, and is of particular benefit to the profoundly deaf. It has been used in teaching deaf mutes to articulate naturally. The particular arrangement of mouthpiece, tube, and transmitter carries effectively the low whispered voice tones.

Fig. 3042.—The Sonor (open).

The *Dentiphone* consists of a thin elastic hard rubber plate shaped like a fan and can be used as such if desired. It is employed to convey sound to the auditory nerve through the medium of the teeth. The external ear has nothing whatever to do in hearing with this instrument. When adjusted for hearing it is placed in a state of tension, contact being made with the upper teeth only. By means of cords as shown in the illustration, the plate may be curved or drawn

Fig. 3043.—The Hand Otophone.

taut, in which condition it will serve the purpose in many instances with very satisfactory results, but it is applicable only in a certain class of cases. To just what forms of deafness the instrument may be applied with success one is unable to state, actual tests of the appliance in each case having thus far been the only means of determining its utility. The dentiphone is made in four styles.

Recently much new apparatus has been put on the market. Among these is the microphone which is simply a flat box with a very delicate film of flexible metal in it so that the air waves are set into vibration. When the telephone came out the same principle was

Fig. 3044.—The Tube Otophone.

used. There is a small receiver, a small battery and the microphone transmitter. The sound-box contains a number of small grains of carbon in order to make a loose contact, but, unfortunately, the carbon grains move around upon the slightest motion of the receiver, and this noise may be so accentuated as to make the use of the instrument very objectionable.

Fig. 3045.—The Dentiphone.

The *Acousticon* is a modification of the telephone principle and is an honest attempt to improve hearing conditions. Some people hear with it very well indeed, while others can never become accustomed to the various confused sounds and vibrations which it

Fig. 3046.—The Acousticon.

brings to their ears. Noises and sounds occur where connection is made between the battery and the resonator, and these things disturb patients very much at first. The ear has to be educated to use an electrical apparatus. Hearing conditions are absolutely changed when using them, and the sounds must be analyzed as they come through the apparatus. They are certainly accentuated.

The acousticon consists of more than 400 parts, but on its surface shows but four parts the battery, earpiece, transmitter and connecting cord. The transmitter is that part of the instrument which is worn on the coat or vest and receives and magnifies the sound. It is constructed to gather sound in a circumference of nine inches and to concentrate the full power of that sound at the extreme point of a sound-focusing cone which is in close proximity to a peculiarly constructed, highly sensitive diaphragm. By means of these and their relations to each other the transmitter can magnify sound from 100 per cent. to nearly 500 per cent. in accordance with the needs of each person, and convey it in its magnified condition to the ears. An electric current picks this magnified sound up at this focused point and carries it to the earpiece. This transmitter must be perfect if it is to give the results for which the acousticon is designed. Every part of the transmitter, diaphragm, and cone must be exact as to thickness and shape. This is one of the principal reasons why the instrument must be as expensive as it is.

The acousticon is made in a great variety of styles and types giving different degrees of strength and clearness of articulation. It is claimed that by adjusting it to the needs of the person in question the hearing can be approved in ninety per cent. of those patients in which the auditory nerve still functionates.

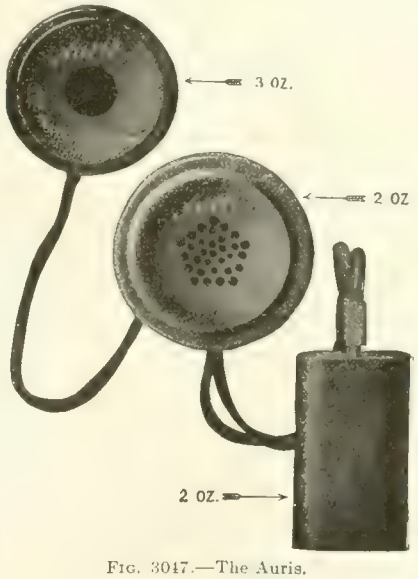

Fig. 3047.—The Auris.

The Type R A acousticon (Fig. 3046) is a new model fitted with the "sound regulator," especially adapted for men's use. The battery and transmitter make one part and the earpiece the other, the two being connected by pliable, silk-covered wire. The battery can be concealed in the vest pocket, the receiver appearing just above and in position to catch the full volume of sound. The earpiece is about as large as a gentleman's watch, and it may be held to the ear in the hollow of the hand or by a headband.

For those who are slightly hard of hearing or who cannot afford as perfect an instrument as the acousticon, the auris (Fig. 3047) is one of the best instruments they can secure. It weighs, complete, only seven ounces, has a battery just half the size of the

acousticon, and is one of the smallest, lightest, and cheapest electrical instruments for the deaf. On account of its small size the Auris is well suited to those who find it especially desirable to have as inconspicuous an instrument as possible. The auris is so small that when packed in the carrying case (which is furnished free) it can be carried in the pocket.

The Mears *aurophone* is very widely advertised and has the advantage of portability. It has a retaining head band to hold it in place. Inside there are several bands of metal which reduce any reverberation and cut down the size of the sound waves. The idea of having a battery and sound receiver in one is a good one, but the advantage lies in the sound receiver. The reflection of sound waves with any instrument is, of course, a matter of prime importance.

With reference to the instruments which depend on the continued stimulation of the auditory nerve, they are to be condemned absolutely. A number of cases have been kept under observation where these instruments have been used for improvement of the hearing, and, without exception, the patients were worse after using them than before.

There are many ways in which patients who are hard of hearing can be helped without having to wear a hearing tube. They should be encouraged to study lip reading. This is very important. Another way is for those addressing them to speak more clearly. It is not always the loudness of the voice; it is the clearness of enunciation which is necessary to accurate hearing. Another important point is the exercise of speech for those who are hard of hearing. Not infrequently the deaf suffer from not knowing how loudly they are speaking. They have nothing to guide them in their own ears.

Prof. John Dutton Wright, Superintendent of the Wright Oral School for the Deaf in New York City has for years been working to teach the deaf and dumb to speak. He was for a time Helen Keller's instructor, and within the past few years has had some remarkable successes. Several of his patients were presented before the Ninth International Congress of Otologists held in Boston during Aug., 1912. There is no doubt that such a method is preferable to the sign language; and, although it requires an infinite amount of time and patience, it is worth all that it costs.

Irving Wilson Voorhees.

Heart, Actinomycosis of the.—Actinomycosis of the heart has been observed a number of times but as the observations of this condition increase so slowly it must be regarded as a very rare occurrence. Since the respiratory tract appears to be one of the most common avenues of entrance of this parasite, secondary involvement of the mediastinum is of frequent occurrence, whereby extension to the pericardium may take place. Because of the similar physical signs and the presence of pus in the pericardial sac actinomycosis of the pericardium is likely to be mistaken for tuberculosis. Besides infection by direct extension from the mediastinum hematogenous metastases in the heart wall may occur, or the heart may be primarily affected, the avenue of entrance being unknown. Paltauf found extensive actinomycosis of the wall of the right ventricle in a tuberculous subject, the condition having been diagnosed as tuberculous pericarditis. In cases observed by Israel, Ponfick, and others, metastases were found in the heart arising from primary foci in the liver, lungs, and other parts of the body (pyemic actinomycosis). Occasionally a general infection of the body, acute or chronic, occurs, and the heart is involved in common with other organs. Actinomycosis of the heart presents no definite clinical picture. The diagnosis of the condition will rest entirely upon the demonstration of the presence of the parasite within the pus obtained from the pericardial sac or elsewhere in the body. The treatment should be directed along general lines, with the internal use of potassium iodide, which in some cases has appeared to have a specific effect upon the fungus.

Aldred Scott Warthin.

Heart, Anatomy of the.—The heart is a four-chambered hollow muscle, divisible functionally into two parts, each consisting of two chambers, an auricle (atrium) and a ventricle. The right half of the heart comprises the right auricle (atrium) which receives the venous blood from the body general through the venæ cavæ, and the right ventricle which receives the blood from the auricle (atrium) through the auriculoventricular (atrioventricular) orifice, and sends it by the pulmonary artery to the lungs. From the lungs the aërated blood is received by the left auricle (atrium) through the pulmonary veins, and by it transmitted to the left ventricle through the left auriculoventricular (atrioventricular) orifice, the left ventricle in turn pumping the blood by way of the aorta back again to the body. This pump is supplied with appropriate valves to determine the direction of the blood stream (see article on *Circulation of the Blood*, vol. ii., p. 133, Fig. 707).

If the heart be removed from a cadaver that has been preserved by injection with a solution of formalin, which so hardens the tissues that they preserve after removal the form they had *in situ*, it is seen to be not so much a conical as a distinctly six-sided organ; the sixth side or upper surface being, however, obscured by the fact that it is almost entirely occupied by the openings of three great vessels, the superior vena cava, aorta, and pulmonary artery (Figs. 3050 and 3055). Two well-marked grooves are distinguishable on the surface of the organ (Figs. 3051 and 3055): the *auriculo-ventricular groove* (coronary sulcus) which marks the separation of the auricles (atria) from the ventricles and lodges the main trunks of the cardiac vessels and corresponding nervous plexuses; and the *interventricular groove* seen on the anterior and inferior surfaces of the heart, which marks the separation of the two ventricles and contains the larger branches of the cardiac vessels. A considerable amount of fat in which the vessels are embedded fills up these grooves and obscures them till dissection makes tham more prominent. The heart, with the proximal portions of the vessels that spring from it, occupies a separate serous cavity in the thorax between the two lungs and pleuræ, called the *pericardium*, the heart with its fibroserous pericardial sac forming the contents of the middle mediastinum (Fig. 3049). Its situation and relations will be readily understood by reference to Figs. 3048 and 3049, the former being self-explanatory, the latter a horizontal section through a frozen body at the level of the eighth thoracic vertebra. Both figures show that the organ is markedly deflected to the left side. Before considering the relations in detail we will make ourselves acquainted with the excised heart. Examined externally the *auricles* (atria) are conspicuous by the thinness of their walls, and mainly occupy the right and posterior aspects of the heart. The *ventricles* are thick-walled, form the greater part of its anterior, left and inferior aspects, and the left ventricle is drawn to a blunt point, which is the meeting place of the three just-named surfaces, and is known as the *apex* of the heart.

The *right auricle* (atrium) (Figs. 3051, 3052, and 3056) on the surface presents a quadrangular outline, and occupies the whole right and part of the anterior, posterior, inferior, and superior surfaces of the heart. At its posterior inferior angle is the *inferior vena cava*; at its posterosuperior angle the *superior vena cava;* while its anterosuperior angle is prolonged into an angular diverticulum which extends round in front of the aorta and is called the *auricular appendix* (auricle). The anterior limits of the two cavæ are united by a

groove on the surface of the auricle called the *sulcus terminalis* (Fig. 3051) which marks off the portion of the auricle formed by union of the two venæ cavæ from that portion which belongs to the primitive auricle. On opening the auricle (atrium) (Fig. 3052)

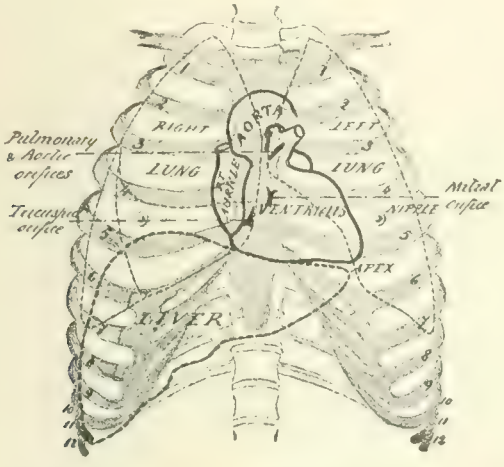

FIG. 3048.—Outline of Heart, Lungs, and Liver to Show their Relations to Each Other and to the Chest Wall. (Heusman and Fisher's "Anatomical Outlines.")

this latter portion is found to present on its inner surface a large number of branching muscular ridges united by a membrane so thin as to be translucent. Over the right wall of the auricle these ridges are fairly regular and nearly parallel. They extend from a prominent crest, the *crista terminalis* (which corresponds in position to the sulcus terminalis), to the region of the auriculoventricular (atrioventricular) groove and are called *musculi pectinati*. In the appendix they are much branched, and run vertically across its cavity.

The rest of the interior of the auricle is smooth and is called the *sinus venosus*. Its left wall in front is in close contact with the commencement of the aorta, and behind this is formed by the septum between the auricles. Here there is a circular depression where the septum is translucent. This is called the *fossa ovalis*, is about five-eighths of an inch in diameter, and is surrounded, except at its lower part, by a prominent muscular ridge, the *annulus ovalis* (limbus ovalis). The ridge is specially prominent above, and under it is a deep recess, closed after birth except for an occasional minute canal through which a probe can be passed, but open during fetal life for the free passage of blood from the right to the left auricle. The opening in the fetal condition is the *foramen ovale*. At the posterosuperior angle of the cavity will be found the orifice of the superior vena cava, large enough to admit the little finger, and unguarded by any valve. At the posterior inferior angle is the orifice of the inferior vena cava, which will admit two fingers. Stretching from the right anterior margin of the inferior caval opening to the anterior limb of the annulus ovalis (limbus ovalis) is a prominent musculo-membranous ridge, the *Eustachian valve* (valvula venæ cavæ inferioris), whose function in the fetus is evidently to guide the blood from the inferior vena cava through the foramen ovale. Its prominence and constancy in the adult seem to show that though its fetal function is lost, it still serves an important purpose in directing the intraauricular blood currents. Its muscular portion consists of a strong bundle of fibers which surround the inferior cava and are attached to the septum, thus possibly constricting the caval opening during auricular systole. On the floor of the auricle, just in front and to the left of the inferior caval opening, is the orifice of the *coronary sinus*, guarded below

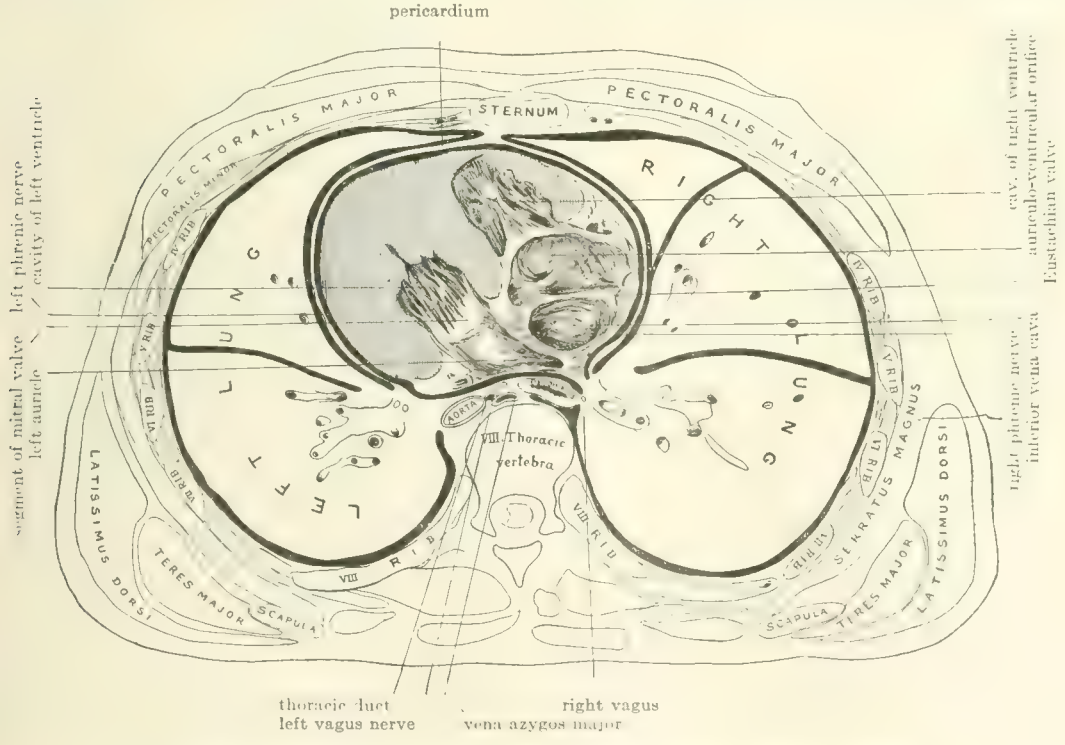

FIG. 3049.—Cross section of Thorax at Level of Eighth Thoracic Vertebra. (Braune.)

by a delicate semicircular valve which is frequently fenestrated and is called the *valve of Thebesius* (valvula sinus coronarii). The anteroinferior angle of the right auricle (atrium) runs into a large funnel-shaped opening, the *auriculoventricular* (atrioventricular) *orifice* (Figs. 3050 and 3052). This opening is oval or triangular in shape, readily admits three fingers, and is guarded by the *tricuspid valve*. In addition to these openings there are scattered over the walls of the auricle numerous small pits and little openings called *foramina Thebesii*, some of which are blind depressions, while others are the orifices of small veins.

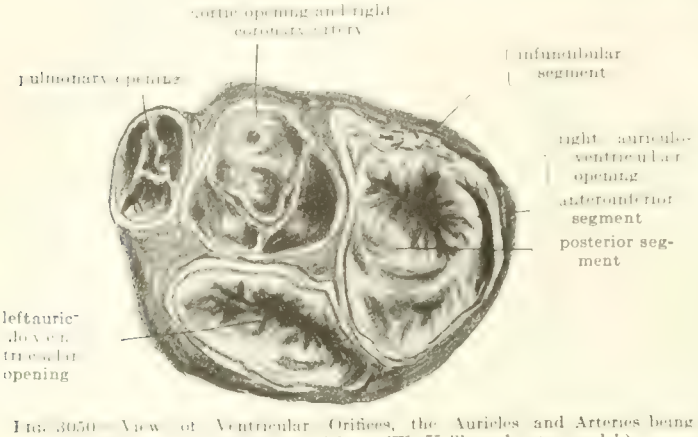

Fig. 3050.—View of Ventricular Orifices, the Auricles and Arteries being Removed Close to the Ventricles. (W. Keiller ad naturam del.)

The *right ventricle* (Figs. 3052, 3055, 3059) occupies the greater part of the anterior surface, and about half the inferior surface of the heart. It practically forms the whole anterior inferior border, but stops short of the left inferior angle of the heart, the so-called apex. When opened it is seen to present a floor and three walls, anterior, left, and posterior, the three walls tapering upward to form a smooth funnel, the *conus arteriosus*, which leads into the pulmonary artery. This orifice is guarded by three semilunar flaps which together form the *pulmonary valve*. The left wall of this cavity is convex, owing to the great thickness of the wall of the left ventricle, and here the blending of the walls of the two ventricles forms the ventricular septum (Fig. 3053). The lower two-thirds of the posterior wall of the right ventricle is occupied by the large *auriculoventricular* (atrioventricular) orifice, the upper third tapering into the conus arteriosus and lying in close relation with the aorta. With the exception of the conus arteriosus, the walls of the ventricles are marked by an intricate network of muscular ridges and bands called *columnæ carneæ* (trabeculæ carneæ), the ridges being mere thickenings of the wall, the bands attached at both extremities and free in the middle. A varying number of these fleshy columns, called *musculi papillares*, end in fibrous string-like bands, the *chordæ tendineæ*, which are attached to the segments of the tricuspid valve. The *tricuspid valve* (Figs. 3050 and 3052), which guards the auriculoventricular orifice, is composed of three triangular segments consisting of fibrous tissue clothed with endocardium, thick at their bases where they are attached around the opening, and thinning off toward their free margins, which are translucent and jagged. The extent to which the flaps are separated varies greatly, while sometimes there are small intermediate lobes between the main segments. Branched, thread-like chordæ tendineæ pass from the ventricular wall or papillary muscles to the free margins, ventricular surfaces, and attached bases of the segments, each papillary muscle or group of muscles sending cords to the contiguous margins of two separate flaps. Thus when the ventricle contracts the blood is forced in behind the cusps which come together and, being prevented by the chordæ tendineæ from bulging too much into the auricle, effectively prevent reflux of blood into the auricle and compel its flow into the pulmonary artery. Of the three segments the anterosuperior is the largest, and separates the conus arteriosus from the auriculoventricular orifice. It is therefore called the infundibular segment. It is smooth on both its auricular and infundibular surfaces. The other segments are placed anteroinferiorly and posteriorly, and the last (being in contact with the septum) is called the septal segment. The *musculi papillares* in the right ventricle vary exceedingly. The best marked springs from the anterior wall and has usually a muscular band of varying thickness, called the *moderator band*, attaching its base to the ventricular septum. It sends chordæ to the infundibular and anteroinferior segments. A group of small papillary muscles occupies the floor and lower part of the septum and supplies chordæ to the contiguous margins of the anteroinferior and septal segments; while from the upper part of the septum, in the conus arteriosus, a few chordæ pass directly without a distinct papillary muscle to the contiguous margins of the infundibular and septal segments. The pulmonary valve is so similar to the aortic that one description will do for both.

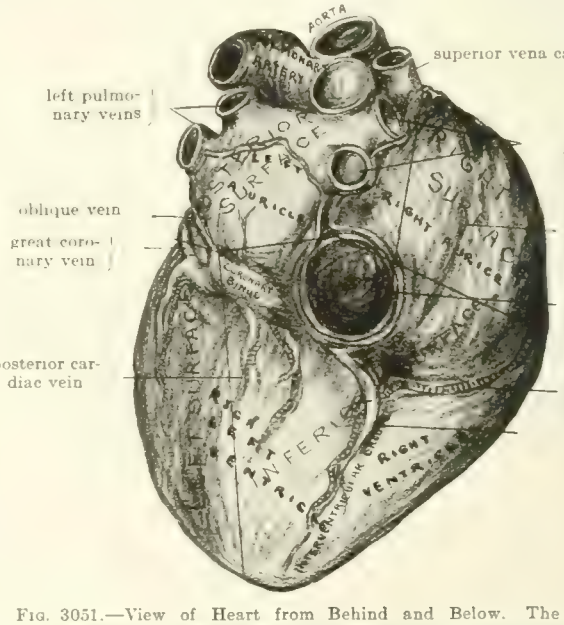

Fig. 3051.—View of Heart from Behind and Below. The surfaces are outlined in black lines. ⅔ (Drawn by W. Keiller, after His.)

The *left auricle* (atrium) (Figs. 3051 and 3058), which occupies the whole posterior surface of the heart, is quadrilateral in outline and slightly convex. At its right and left margins are the openings of the *right and*

left pulmonary veins, usually two of each. They vary greatly in size and situation. The left *auricular appendix* (now simply called the auricle) extends upward and forward from its left superior angle and slightly overlaps the pulmonary artery in front and to the left of that vessel (Fig. 3055). The left auricle

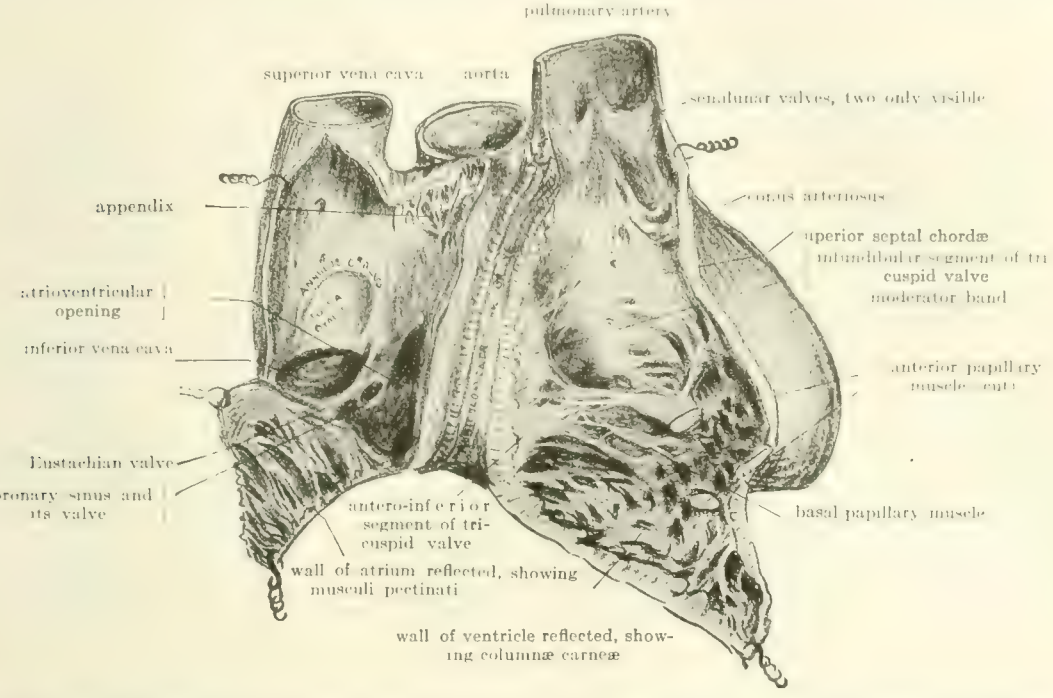

Fig. 3052.—Right Auricle and Ventricle Opened, Somewhat Stretched Out for Better Display. (Drawn from nature by W. Keiller.)

(atrium) is somewhat thicker walled than the right. On the interior the walls are smooth and the musculi pectinati are few and short and almost entirely confined to a small part of the roof and appendix. The posterior wall and floor are smooth. The left wall is narrow and presents the openings (usually two) of the left pulmonary veins; the right wall has posteriorly usually two, seldom three openings of the right pulmonary veins; none of these has valves. In front of these the right wall is formed by the interauricular septum, and presents superiorly one or two semilunar

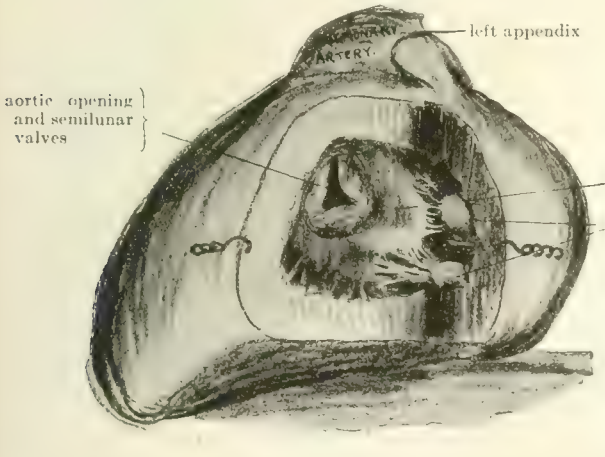

Fig. 3053.—View of Opened Left Ventricle, much Foreshortened (W. Keiller ad naturam del.)

place, and there is no evidence of the last having caused any cardiac embarrassment. The anterior wall in the upper part lies in close relation with the conus arteriosus of the left ventricle and commencement of the aorta; and its lower half is occupied by the obliquely placed somewhat oval *auriculoventricular* (*atrioventricular*) or *mitral orifice* (Fig. 3050) which admits two fingers easily, thus being distinctly smaller than the corresponding orifice on the right side. It is guarded by the *mitral valve.*

The *left ventricle* (Figs. 3057 and 3053) forms the whole left surface of the heart, a small portion of its anterior, and about half its inferior surfaces. On cross-section its outline is seen to be almost circular, its walls being at least twice as thick as those of the right ventricle, which therefore moulds itself to the thicker-walled cavity and assumes a crescentic outline (see Fig. 3054). Its cavity is long and conical, the apex of the cone running to the extremity of the so-called apex of the heart which is thus formed by the left ventricle. The base of this conical cavity presents two orifices (Fig. 3053), the lower of which points backward and opens into the left auricle, and is guarded by the *mitral valve;* while a smooth funnel-like portion runs upward, backward, and to the left into the *aortic opening,* this last being somewhat smaller than the atrioventricular opening, and guarded by the *aortic valve.* The *columnæ* (*trabeculæ*) *car-*

mur are short, thin, much branched and best marked at the apex of the conical cavity. The *mitral valve* is composed of two large, well-marked segments, thicker and stronger than those of the tricuspid valve, and between them are two distinct subsidiary flaps. Two large prominent *musculi papillares*, springing respectively from the left and inferior walls of the cavity,

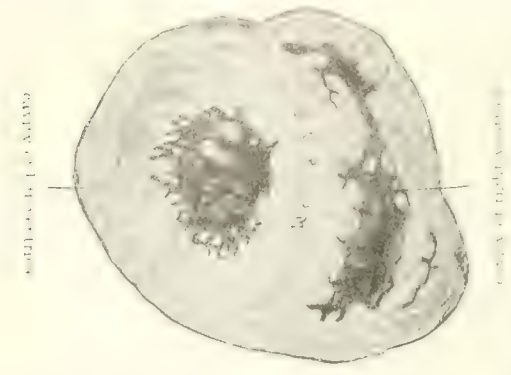

Fig. 3054.—Crosssection of Heart through Ventricles. (W. Keiller, ad naturam del.)

send chordæ tendineæ to the upper and lower margins of the valvular segments respectively. They are so situated that when contracted with the ventricular systole they pull the margins of the segments together. Of these two segments, the anterior or *aortic segment* separates the auriculoventricular from the aortic orifice (Fig. 3053), and is smooth on both its convex margins are attached to the ring round the aortic orifice, and their straight edges are free. Thus three pouches are formed open toward the aorta, into which the blood flows when the systole passes off, and thus brings the three segments together so as effectively to stop regurgitation of blood into the ventricle. The aortic wall bulges slightly at each pouch, and each bulging is named a *sinus of Valsalva*. These sinuses in the aorta are arranged, one anteriorly, two posteriorly, and from the anterior sinus springs the *right coronary artery* (Fig. 3050), while the *left coronary artery* springs from the left posterior sinus. Each segment of the valve has at the middle of its free edge a fibrous body, the *nodulus* (*Arantii*), toward which the stronger fibers radiate so as to leave an exceedingly thin, sometimes fenestrated lunated margin on either side of it, called the *lunula*. The free margin of the valve is strengthened by a fibrous band. The portion of the ventricle which leads up to the aortic orifice is so strengthened by fibrous or fibrocartilaginous tissue as to remain uncollapsed during diastole. The septum between the ventricles is thick and muscular, except for a small area where the aorta springs from the septum. This is the *pars membranacea* of the septum, and here a congenital defect in the septum may cause an abnormal communication between the ventricles.

Relations and Surfaces of the Heart.—As has been already pointed out, the heart is a six-sided or cuboidal body, presenting anterior, right, left, posterior, inferior and superior surfaces. The *anterior* surface (Fig. 3055) is the first which meets the eye when the thorax is opened. It is triangular in shape, the apex of the triangle being completed by the merging of its upper limit into the aorta and pulmonary artery. It is slightly convex and is directed forward and a little

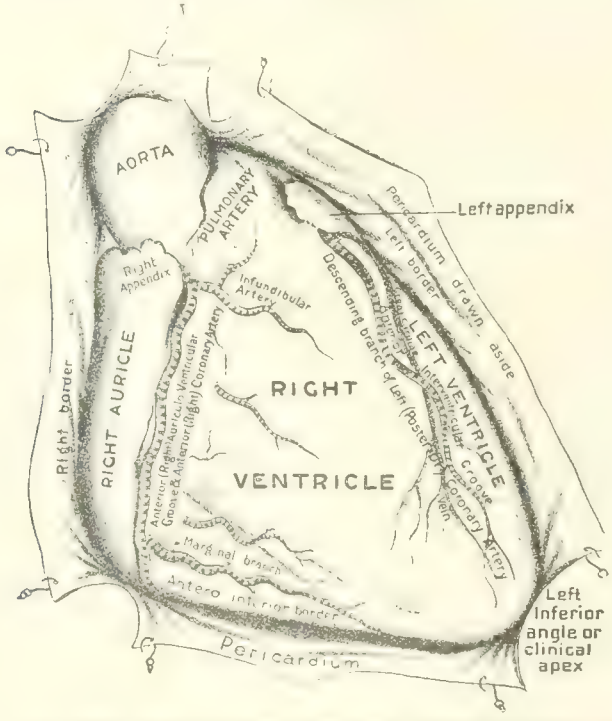

Fig. 3055.—Anterior Surface of the Heart, Pericardium Opened (W. Keiller ad naturam del.)

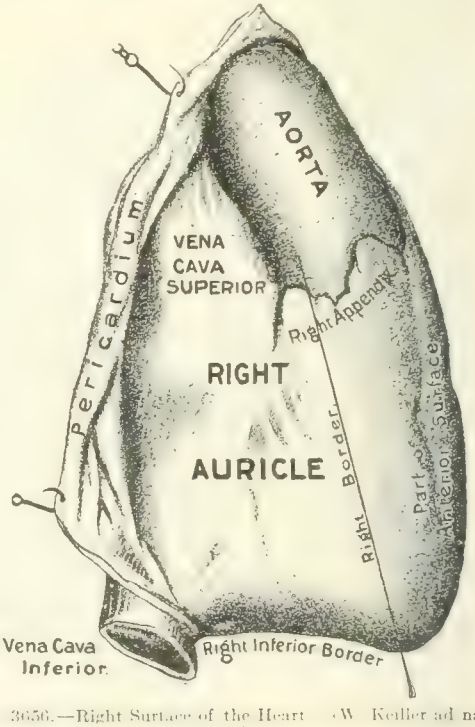

Fig. 3056.—Right Surface of the Heart (W. Keiller ad naturam del.)

auricular (atrial) and its ventricular surfaces, the chordæ being attached to its margins only. The *aortic valve* is composed of three semicircular or semilunar folds of fibrous tissue lined below by the endocardium and above by the intima of the aorta. Their upward, being in sagittal mesial section parallel with the sternum. In it are included the greater part of the right ventricle and portions of the left ventricle, left auricular appendix, right appendix, and part of the right auricle. It is bounded below by the sharp,

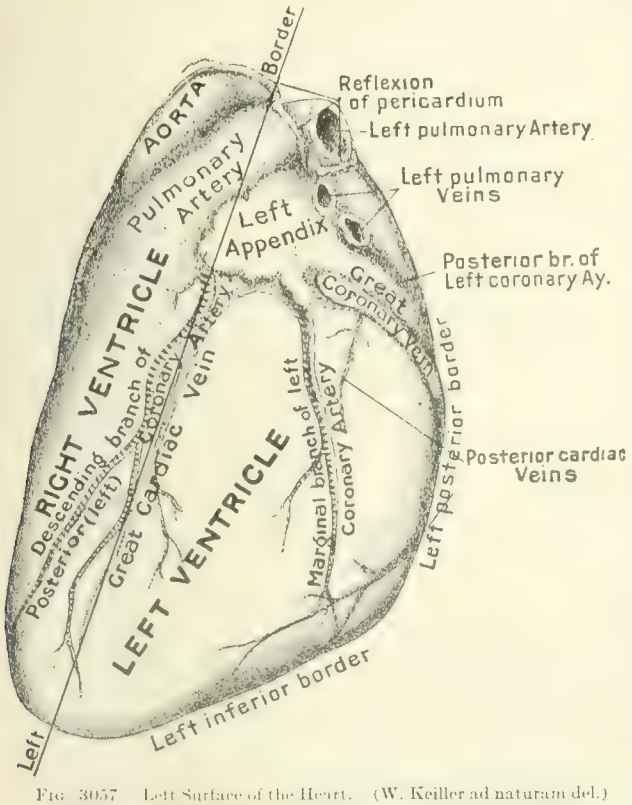

Fig. 3057.—Left Surface of the Heart. (W. Keiller ad naturam del.)

almost straight *anteroinferior* border (*margo acutus*, inferior border of clinicians), on the right by the nearly vertical and convex *right anterior* border (right border of clinicians), and on the left by the oblique, convex, and slightly rounded *left anterior border* (left border of clinicians). Its left inferior angle forms the *clinical apex*. *Relations:* Separated from it by the pericardium (Fig. 3049) are of the margins of the lungs and pleuræ, sternopericardial ligaments, triangularis sterni (transversus thoracis), internal mammary vessels and sternum, with the fourth, fifth, and sixth left costal cartilages.

The *right surface* (Fig. 3056) is markedly convex four-sided, lies almost vertically, and is directed toward the right. It is composed of the greater part of the right auricle. Its anterior, posterior, and inferior borders are only slightly rounded and are therefore well defined. At its superior extremity the surface blends with the wall of the vena cava superior and its posterior inferior angle is similarly related to the vena cava inferior. *Relations* (Fig. 3049): It is separated by pericardium from the phrenic nerve and vessels, pleura, and inner (medial) surface of right lung.

The *left surface* (Fig. 3057) is a convex triangular area directed mainly upward and toward the left. It includes about one-half of the free surface of the left ventricle and left auricular appendix. It is separated from the anterior surface by the left anterior border; from the inferior surface by a rather sharp left inferior border; and behind it is bounded by the left pulmonary veins and left auriculo-ventricular groove, with the great coronary vein embedded therein. *Relations* (Fig. 3049): It is separated by the pericardium from the left phrenic nerve and vessels, left pleura, and inner (medial) surface of left lung.

The *posterior surface* (Fig. 3058) is called the base in text-book descriptions. It is four-sided, convex, vertical, and directed backward. It is formed by the left auricle (atrium) and by the portion of the right auricle (atrium) which joins the two venæ cavæ, and is bounded below by the inferior vena cava and coronary sinus, above by the right pulmonary artery, on the right by a fairly defined border joining the two venæ cavæ, and on the left by the left pulmonary veins and great coronary vein. It is only partially invested by the visceral layer of the pericardium. *Relations* (Fig. 3049): It is separated by pericardium from the bronchi, esophagus, vagi, descending aorta, vena azygos major and thoracic duct.

The *inferior, diaphragmatic surface or true base* (Fig. 3059) is quadrilateral, slightly convex when the ventricles are distended or in systole, slightly concave when they are relaxed and empty. It is directed downward and a little backward and toward the right, and is bounded by rather sharp and well-defined borders. It includes a small portion of the right auricle (atrium) and opening of the inferior vena cava, the rest of the surface being about equally divided between the right and left ventricles. Behind the inferior vena cava is seen a small portion of the left auricle (atrium). It presents the inferior extremities of the right and left auriculo-ventricular grooves, and the inferior interventricular groove. *Relations* (Fig. 3048): It is separated by the central tendon of the diaphragm and some diaphragm

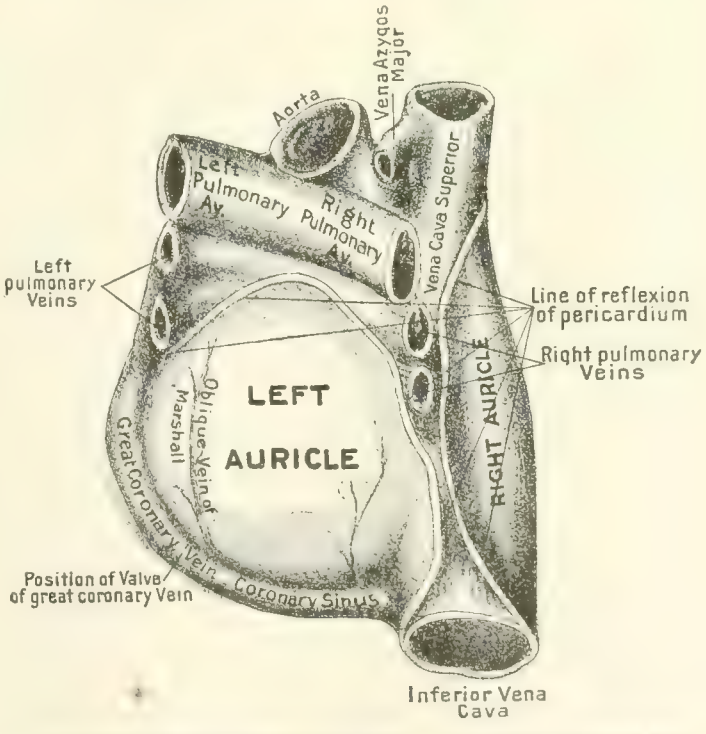

Fig. 3058.—Posterior Surface of the Heart. (W. Keiller ad naturam del.)

muscle from the superior surface (impressio cardiaca) of the liver. Its close relation to the fundus of the stomach will help to account for the cardiac embarrassment apt to be caused by acute distention of that viscus.

The *upper surface* gives origin to the aorta, pulmonary artery, and superior vena cava, and is partly formed by both auricles, especially the left. These vessels spring from the heart on a level with the upper margin of the third costosternal articulation, along a line extending one inch and one-half to the left and one inch to the right of the middle line.

Superficial indications (Fig. 3048): The *upper limit* of the heart has just been indicated. The *clinical apex*, or apex beat, is felt between the fifth and sixth ribs, three and a half inches to the left of the middle line. The *anteroinferior border* is indicated on the chest wall by an oblique line, slightly convex downward, extending from the clinical apex on the left, across and slightly upward to a point one inch to the right of the middle line at the level of the sixth chondrosternal articulation. Along this line the cardiac blends insensibly with the hepatic dulness. These lines being drawn, the *right and left borders* of the heart's anterior surface or the absolute lateral limits of the heart's dulness will be defined by convex lines joining respectively their right and left extremities. Thus, on a level with the fourth chondrosternal articulations, the area of the heart's dulness extends three inches to the left and one inch and three-quarters to the right of the middle line.

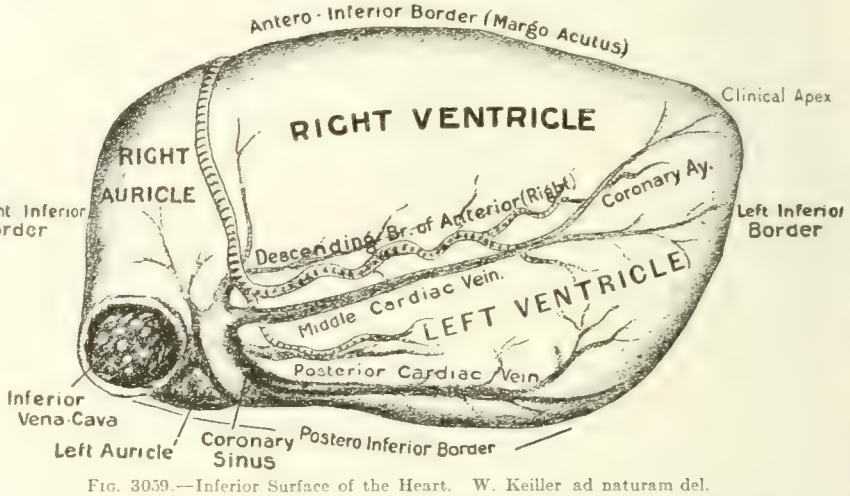

FIG. 3059.—Inferior Surface of the Heart. W. Keiller ad naturam del.

The *pulmonary* and *aortic valves* lie behind the left half of the sternum on a level with the lower border of the third costal cartilage. The *right atrioventricular* opening lies behind the sternum on a level with the fourth intercostal space and fifth cartilage. The *left opening* is a little higher and more to the left. (Compare Figs. 3048 and 3050, it being remembered that the surface represented in Fig. 3050 lies obliquely so as to point very decidedly toward the right.)

In children the heart is relatively broader and projects more to the left than in the adult, and the apex beat may be in line with the nippe or external to it.

Structure of the Heart.—The heart is invested externally by a fibroserous membrane, the *epicardium*, under which lies, especially along the interventricular and auriculoventricular atrioventricular grooves, a variable amount of fat with the main trunks of the cardiac vessels embedded therein. Its cavities are lined internally by a smooth endothelial lining, supported by a delicate fibrous membrane (the *endocardium*), the main substance of the heart is composed of muscular tissue (*myocardium*), the intricate arrangement of whose fibers will be found described in the article on *Circulation of the Blood* (vol. ii., p. 143). The valves are avascular and composed of fibrous tissue with an endocardial lining; while in the region of the ventricular orifices are fibrous rings, and between the aorta and auriculoventricular orifices there is a central fibrocartilage.

Blood-vessels of the Heart.—The *right coronary artery* (Figs. 3050, 3055, and 3059) arises from the anterior sinus of Valsalva (aortic sinus) passes forward between the pulmonary artery and right appendix, and follows the right auriculoventricular groove (coronary sulcus) till it reaches the inferior interventricular groove where it divides into two branches, of which the smaller *transverse* or *auriculoventricular* (atrioventricular) branch continues in the left auriculoventricular groove (coronary sulcus) for some little distance, and the large *descending* (or better, *interventricular*) branch follows the inferior interventricular groove, supplying both ventricles and the septum. This vessel in its course supplies the right auricle (atrium) and ventricle, aorta and pulmonary artery. Besides the terminals it gives off two named branches, an *infundibular* branch to the front of the right conus arteriosus, and a *marginal* branch which follows the anteroinferior border to the apex. The *left coronary artery* (Figs. 3055 and 3057) arises from the left sinus of Valsalva, passes behind and then to the left of the pulmonary artery, and appears between that vessel and the left auricular appendix. Here it divides into two branches, the *anterior descending* or *interventricular* branch following the anterior interventricular groove to the apex of the heart; the *transverse* or (*atrioventricular*) branch following the left auriculoventricular groove (coronary sulcus). A considerable marginal branch follows the left anterior border of the heart. It supplies the aorta, pulmonary artery, left auricle, and ventricle. The two vessels anastomose minutely with each other on the heart and with the pericardial and bronchial vessels on the walls of the aorta and pulmonary artery.

The great cardiac or coronary vein, commencing near the apex of the heart (Fig. 3055), accompanies the interventricular branch of the left coronary artery in the anterior interventricular groove; beneath the left appendix it curves backward in the (coronary sulcus) and joins the left end of the coronary sinus (Fig. 3058) where its opening is guarded by a valve. Three or four veins, called *posterior cardiac*, but better called left and inferior cardiac veins, course over the left and inferior surfaces of the left ventricle, joining the great coronary vein and coronary sinus. The *middle cardiac vein* (Fig. 3059), commences at the apex of the heart and follows the inferior interventricular groove with the descending (interventricular) branch of the right coronary artery. It joins the right extremity of the coronary sinus. The *small* or *right coronary vein* (Fig. 3059) runs toward the left in the right auriculoventricular groove to join the right end of the coronary sinus. The *coronary sinus*, about one inch in length, occupies the inferior extremity of the left auriculoventricular groove (Fig. 3059).

It receives the veins above mentioned, all of which are guarded by valves where they join the sinus; and empties into the right auricle in front of the inferior canal opening. Its opening is guarded by the valve of Thebesius (Fig. 3052). In addition to the above a small vein, the *oblique vein* of Marshall, runs downward and over the back of the left ventricle to join the coronary sinus (Fig. 3058). This vein is interesting inasmuch as it, with the coronary sinus, represents the left superior cava of the embryo.

The *anterior cardiac veins* are two or three small veins which pass from the anterior surface of the right ventricle directly into the right auricle. They have no valves. Minute veins (the *venæ cordis minimæ*) open directly into the auricle and ventricles.

Lymphatics.—The cardiac lymphatics spring from all parts of the heart substance, from a network beneath the epicardium, thence accompany the coronary arteries, and empty into the anterior mediastinal lymph glands.

The cardiac nerves are described in the article on *Blood, Circulation of the* (vol. ii.).

William Keiller.

Heart, Anemic Infarction of the.—The occlusion of a branch of a coronary artery, if not immediately fatal, is followed by an anemic necrosis of the part of the heart wall supplied by the occluded vessel. The necrosed area is known as an anemic or white infarct or as *myomalacia cordis*. The terminal branches of the coronary arteries possess but a very limited collateral anastomosis. The area of necrosis produced by the occlusion of a terminal branch corresponds to the physiological distribution of the affected vessel but is somewhat smaller in area. Infarction occurs most frequently in the portion of the myocardium supplied by the anterior coronary artery, the most common location being in the wall of the left ventricle near the apex. The medium-sized and smaller branches are the ones most frequently obstructed.

The occlusion is usually produced by thrombosis or embolism. Thrombosis is favored by sclerotic changes; under certain conditions coronary sclerosis or syphilitic endarteritis may give rise to infarction without the occurrence of thrombosis or embolism. In such cases the nutrition of the muscle already impaired by the partial obstruction of the vessel caused by sclerosis may be so much further lowered by general circulatory disturbances that the integrity of the muscle can be no longer preserved. Thrombi are of much more frequent occurrence in the coronary vessels than emboli; their formation is directly dependent upon the occurrence of atherosclerotic or syphilitic changes in the vessel wall. Of all the causes of infarction of the heart muscle syphilitic changes in the coronary vessels are by far the most common and important. The progressive infarctions of the heart wall are practically always syphilitic. The entrance of emboli into the coronary vessels is of rare occurrence. This fact is explained by the anatomical peculiarities of the coronary arteries, the location of their orifices, angle of divergence with the aorta, force of current, etc. Embolism, however, occasionally occurs; the embolus usually consists of a portion of a thrombus primary in the left heart, either parietal or formed upon the mitral or aortic valves. In other cases the embolus may consist of atheromatous material derived from the vessel wall above the point of occlusion. Septic emboli occur in cases of malignant endocarditis; they are more frequently derived from vegetations on the mitral than on the aortic valve. In whatever way produced, coronary occlusion leads immediately or very quickly to anemic necrosis, the slight capillary anastomosis and the Thebesian vessels being inadequate to the task of supplying sufficient nutrition to the affected area.

Infarcts occur most frequently in the papillary muscles and in the wall of the left ventricle and septum, more rarely in the right ventricle. In the posterior wall of the left ventricle they are more common in the upper portion, anteriorly they are more common toward the apex. They are more common in the middle layers of the myocardium, less frequently do they extend to the epi- or endocardium. The necrotic area is always smaller than the area supplied by the obstructed vessel. The obstruction usually lies outside of the necrotic area. Small infarcts may become confluent until the entire anterior or posterior wall is involved.

The infarct is yellowish or grayish-red in color and of a cloudy, parboiled appearance. The consistence is somewhat softer than that of the normal muscle, and the recent infarct is slightly elevated. Subsequently it becomes softer and depressed. The heart infarct is rarely wedge-shaped, as is so frequently the case in infarction of other organs; but the contour is irregular, areas of living muscle alternating with dead tissue. This irregularity of distribution is due to the peculiar overlapping of the coronary branches, as a result of which adjacent muscle bundles may receive their blood supply from terminal branches arising from different main trunks of the third or fourth degrees. This fact is of great importance in the heart economy in so far as the occurrence of infarction is concerned. Occlusion of the smaller terminals does not lead to an infarction extending entirely through the heart wall, and the chances of rupture or aneurysmal dilatation are thereby much lessened. Around the periphery of the infarcted area there is almost always a narrow zone of hemorrhage and congestion outlining the yellowish dead muscle with a border of red. This is to be regarded as being of the nature of a narrow zone of hemorrhagic infarction in the limited area of collateral anastomosis between the occluded vessel and the neighboring terminal. Large hemorrhages occasionally occur about the infarct; these may extend in between the dead muscle bands of the anemic area, giving it the appearance of a hemorrhagic infarction. Infarcts of small size do not usually involve either the peri- or the endocardium, but larger ones are accompanied by the formation of thrombi on the endocardium and localized areas of pericarditis.

On microscopical examination the muscle fibers in the central portion of the infarct show a condition of simple necrosis, their nuclei having completely disappeared, and the muscle protoplasm presenting a more or less homogeneous appearance, staining deep red with eosin. Occasionally extensive fragmentation or Zenker's necrosis may be present. Around the periphery of the completely necrosed area there is usually found a zone of diffused chromatin, the muscle nuclei at this point showing beginning or partial disintegration. Bordering upon this zone is the area of partially damaged muscle with greatly congested vessels and extensive interstitial hemorrhage. If the infarct is not of very recent occurrence extensive leucocyte infiltration may be found around the periphery, or evidences of repair in the formation of granulation tissue. Numerous phagocytes wander into the dead area and take up both muscle- and blood-pigment. New blood-vessels are but sparingly formed. In older infarcts the dead muscle is almost or wholly replaced by new connective tissue at the periphery, in which numerous hypertrophic muscle fibers may be present. Scattered throughout infarcts of large size small islands of living heart muscle are usually found corresponding to the distribution of neighboring branches. The boundary between such areas and the necrosed muscle usually shows a narrow intermediate zone of partial necrosis, diffused chromatin, and hemorrhage. In the majority of infarcts there is usually present a narrow line of living muscle just beneath the peri- and endocardium, which is to be explained by the presence of small collateral branches running beneath these surfaces.

The regeneration of heart-muscle fibers in or around healing infarcts takes place only to a very limited extent. Evidences of this are seen in greatest degree in week-old infarcts. The division figures are never very numerous, and soon disappear. It is probable that the new cells formed quickly degenerate. Hypertrophic muscle fibers are often very numerous in the immediate neighborhood of a healing infarct. This must be regarded as being of the nature of a compensatory hypertrophy. Whether an increase in the number of fibers takes place or not cannot at present be positively stated. Ultimately infarcts of small size are completely replaced by scar tissue containing many elastic fibers, and the area of induration thus formed appears as a white tendinous patch or band in the heart muscle (cicatrix myocardii). Pigmented phagocytes may be found in the scar for a long period after healing. The designation of fibroid heart or fibrous myocarditis is applied to this condition as well as to the areas of sclerosis due to obliterating endarteritis. Practically all fibroid areas in the myocardium visible to the naked eye are to be regarded as healed infarcts.

Septic infarction may occur in cases of pyemia, the smaller branches of the coronary arteries may be blocked with septic emboli. Purulent inflammation of the vessel wall and the neighboring tissue results, and the area of infarction becomes converted into an abscess. Usually death results from the general condition before these develop into abscesses of large size. In the majority of cases they appear as pinhead abscesses, rarely as large as a pea. Very rarely they may reach such a size as to perforate into the heart cavity or into the pericardium, forming what has been termed acute cardiac ulcer. Embolic aneurysmal dilatation of the affected coronary branch may result at the point of embolism, and rupture of this may lead to the formation of a dissecting aneurysm of the heart wall.

As a result of anemic infarction of the heart death may occur instantaneously from the disturbance of the cardiac circulation and the arrest of the fibrillary contractions. In all cases of sudden death occlusion of the coronary vessels should be carefully sought for. Particularly is this the rule in medicolegal examinations. Death may occur before recognizable changes in the structure of the muscle take place. In other cases it may not result for some time after the occlusion of the vessel. It has been shown by animal experiments that the heart muscle is capable of contraction for nearly twelve hours after ligation of the coronaries. At the present time it is impossible to say whether death occurs at the moment of occlusion of the vessel or at the moment of muscle failure. With the softening of the infarcted area either rupture or aneurysmal dilatation of the cardiac wall may take place. Sudden death may be caused by the former event. When the infarcted area lies close to the endocardium the injury to the latter leads frequently to the formation of a cardiac thrombus. Such thrombi are most frequently found in the left ventricle near the apex, and may so block the ventricle that the thrombus may be the immediate cause of death. In eight cases of sudden death autopsied by the writer the cause of death was an obturating thrombus of the left ventricle adherent to the thickened endocardium over an area of anemic infarction resulting from a progressive syphilitic endarteritis of the right descending anterior coronary. After healing of an infarct the cicatrical tissue may give before the blood pressure and produce an aneurysm. In many cases there is a progressive occlusion of the coronary branches with the production of multiple infarcts. A very extensive degree of fibroid heart may result from the healing of these.

The symptoms of anemic infarction are usually those of angina pectoris. The direct relation between the anginal attack and the moment of infarction has not been sufficiently emphasized. The cases of sudden death are quite frequently preceded by an intense but brief attack of this nature. In other cases there are no definite cardiac symptoms. Infarcts or infarct-scars in the septum involving the bundle of His have been regarded as a cause of Adams-Stokes symptom-complex. After healing of the infarcted areas the clinical picture is that of fibrous myocarditis. Prognosis and treatment will be considered under that head.

ALDRED SCOTT WARTHIN.

Heart, Aneurysm of the.—The term aneurysm of the heart is applied to three very different conditions: aneurysms of the coronary vessels, pouch-like projections of the valves, and local dilatations of the heart wall. The original use of the expression cardiac aneurysm was that of Auenbrugger and Corvisart, who applied it to all cardiac enlargements of the nature of hypertrophy or dilatation, distinguishing the two as *aneurysma passivum* and *aneurysma activum*. This conception continued up to the time of John Hunter and Matthew Baillie with whom the term took on its modern significance of a partial dilatation of the cardiac wall. In accordance with this idea the condition is often spoken of as partial aneurysm, though in the majority of cases cardiac aneurysm is taken as referring to aneurysm of the wall alone, coronary and valvular aneurysms being considered under separate heads.

ANEURYSM OF THE CORONARY ARTERIES.—Aneurysmal dilatations of the coronary branches of the second and third degree occur as the result of sclerosis or embolism. They are usually multiple, but may be found singly. They vary in size from a mustard seed to a large cherry, and occasionally form small nodular enlargements scattered over the heart, lying just beneath the epicardium. They are found in greatest numbers and of largest size when due to septic emboli. The symptoms are those of myocarditis. They may rupture either into the pericardial cavity or into the heart wall, in the latter case forming dissecting aneurysms which may be mistaken for true aneurysms of the cardiac wall.

ANEURYSM OF THE HEART WALLS.—Localized dilatation of the heart wall may be congenital or acquired. In the latter case it is due either to trauma or to some pathological condition diminishing the resistance of the heart muscle in localized areas.

Congenital Form.—In defective development of the heart muscle aneurysmal or hernial projections of the endocardium may occur between the muscle bundles. As a result of congenital abnormal thinness of the cardiac wall aneurysmal dilatations may occur in any part of the heart, most frequently in the membranous portion of the ventricular septum. The occurrence of congenital aneurysms in individuals reaching maturity is, however, very rare, the majority of the cases being found in infants or young children.

Acquired Form.—In the majority of cases this is due to fibroid changes in the heart muscle following coronary obstruction, to anemic infarction, or syphilitic infiltration, less frequently fatty degeneration, mural endocarditis, and wounds of the heart. It is not of common occurrence, though cases have been reported with increasing frequency in late years. In 1867 Pelvet collected the cases published up to his time, and in 1883 a similar collection was made by Legg, who found in the literature the reports of 90 cases. Since his article new observations have been constantly made, and the number of recorded cases is now over 300. According to Willigk, 170 cases of cardiac aneurysm were found in 34,000 autopsies. The acquired dilatation may be acute or chronic; according to its manner of formation it may be a pouch-

like dilatation communicating with the heart cavity through a large opening, or it may be saccular with a very small opening, or the aneurysm may be of the dissecting variety. Rarely it may be multilocular, consisting of a number of intercommunicating sacs.

The majority of cases occur in males of advanced age, but a number of cases in young men have been reported, and one in a young girl of twelve years. In the younger cases the condition is almost always the result of syphilitic weakening of the wall. The usual seat of the aneurysm is in the anterior wall of the left ventricle near the apex, occurring in this location in fifty-nine of the ninety cases reviewed by Legg. The septum is involved next in point of frequency, then the posterior wall of the left ventricle near the base, while the auricles and right ventricle are only very rarely affected. Usually the aneurysm is single, but very rarely localized dilatations have been found in all four of the heart cavities. In the auricles the whole wall may be involved in the dilatation. Occasionally a number of dilatations, in one of the reported cases four, have been found side by side, their walls in apposition. The aneurysmal dilatation of the septum usually protrudes into the right ventricle, only one case having been recorded of its projecting into the left.

The size of the aneurysm may vary greatly, from the size of a fist to a man's head. They are usually flat, but may be globular. The larger the sac, the thinner the wall. The latter is composed chiefly of dense hyaline connective-tissue. In very large sacs it may be as thin as paper without any traces of heart muscle remaining. The sac may be filled with a soft or firm thrombus. This may become calcified and the sac thus obliterated. Induration and calcification of the sac wall may also occur. Usually the pericardium becomes adherent to the epicardium over the sac, so that eventually the wall of the sac may consist of the endocardium and both the visceral and the parietal portions of the pericardium.

The acute dilatation of the heart wall is usually due to anemic infarction or septic myocarditis, rarely to direct trauma of the heart, as in the case of stab wounds. In some cases localized degeneration or necrosis of the endocardium may make the latter the place of least resistance. The softened membrane yields to the blood pressure, is torn, blood passes through the rent and gradually undermines the heart muscle. When the area of softening is primary in the muscle the endocardium overlying the weakened spot is stretched or torn, forming a cavity into which the blood forces its way. In this manner the weakened area gradually bulges out more and more until there is a definite pouch formed. Acute aneurysms usually increase very rapidly in size, in some cases becoming as large as the heart, so that the condition has been regarded as one of double heart. Though the sac may become filled with blood clot, the wall never acquires a sufficient power of resistance, and the dilatation usually proceeds until rupture occurs.

Chronic aneurysm in the great majority of cases is the result of fibrous changes in the heart muscle. The connective tissue lacking the power of contraction against the blood pressure during systole gradually becomes stretched outward or a cavity may be formed in the wall connected with the ventricle by a narrow opening. By many writers syphilitic myocarditis is regarded as the most common cause of cardiac aneurysm of the slowly progressive type. That the fibrous changes are directly the result of syphilis cannot be proved in the majority of cases; much rather is the process to be looked upon as being of the nature of a chronic anemic infarction due to the progressive narrowing of the coronary arteries through sclerotic changes, which may be due to syphilis or to other causes. In a number of cases, however, the dilatation has been found to be the direct result of gummatous changes in the cardiac wall. Further, the occurrence of coronary sclerosis and fibrous changes in the heart muscle in young individuals may be quite safely regarded as being due to syphilis. Anemic infarction plays a much greater part in the causation of chronic aneurysm than is accorded to it by the majority of writers. Small infarcts are replaced by connective-tissue, and up to certain limits the tone of the wall may be preserved, but if the general tone be diminished by fatty degeneration, atrophy, etc., the area of connective tissue offering the least resistance gives way and dilatation occurs at this point. Localized areas of fatty degeneration, atrophy, etc., may of themselves be the primary factor in the production of aneurysm.

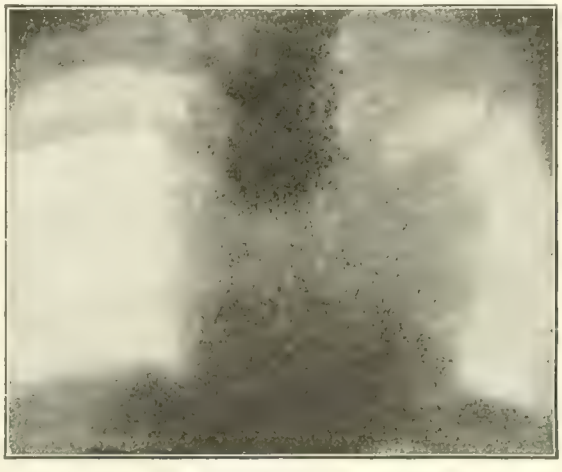

Fig. 3060.—Skiagram of a Case of Cardiac Aneurysm. (After Walsham.)

Dissecting Aneurysm.—The dissecting variety of cardiac aneurysm deserves especial mention. Vestberg has made the most complete study of this condition. He defines it as a pathological cavity communicating with the heart or beginning of the aorta, caused by a separation of the layers of the cardiac wall by the blood. Four varieties are distinguished: parietal, septal, valvular, and interparietal. To these might be added a fifth variety when the cavity is formed between the layers of pericardial adhesions. According to Vestberg, the total number of dissecting aneurysms is sixty. Of these forty-seven were interparietal or septal. In thirty cases the left ventricle was the site of the aneurysm. The interparietal form occurs in the periaortic space of Vestberg, from which the blood may dissect into the auricular or ventricular septum. In sixteen cases the point of origin was in the sinus of Valsalva. Acute ulcerative endocarditis is the cause in the majority of cases; in other cases abscess, atheroma, and trauma were the causal factors. Dissecting aneurysms of the aorta may extend into the walls of the heart and through secondary rupture become converted into dissecting cardiac aneurysms.

Diagnosis.—The diagnosis of cardiac aneurysm is in the majority of cases impossible; it is usually made at the autopsy table. In the case of acute aneurysm the symptoms are those of acute myocarditis; in the chronic form they cannot, as a rule, be separated from those of chronic myocarditis. Symptoms of angina pectoris are usually present. The aneurysm is usually so small as to present no characteristic physical signs. In rare cases the sac has caused erosion of the thoracic wall, forming a visible tumor. The results of percussion and auscultation are very uncertain guides, and though in individual cases unusual murmurs may be produced, they are not constant or characteristic enough to be of diagnostic significance. The Röntgen ray has recently been applied to the differential diagnosis of this condition, and the location, size, and form of the aneurysmal dilatation have been shown by this means.

Prognosis.—The prognosis in the majority of cases is not favorable. In early and undoubted syphilitic cases it is relatively better. The terminations are very variable. After reaching a certain degree of dilatation the process may remain stationary. The sac may be obliterated by thrombosis; calcification of the thrombus may occur. Death usually results from thrombosis of the left ventricle or cardiac insufficiency to which other factors than the aneurysm may contribute. In other cases gradual increase of size with resulting rupture takes place.

Treatment.—The treatment in suspected cases is along the general lines indicated in myocardial and valvular diseases. The possibility of syphilis should always be considered, even when the Wassermann reaction is negative. Aldred Scott Warthin.

Heart, Animal Parasites of the.—Animal parasites are but rarely found in the human heart. The echinococcus is the most frequent and the only one likely to give rise to serious symptoms. The heart is involved in about one per cent. of all cases of echinococcus infection. In a large per cent. of all cases the heart alone was affected. The cysts are found much more frequently in the right side of the heart (ventricle). They may vary in size from a pinhead to an orange or even larger. In one case in which the hydatid was situated in the left ventricle the enlargement of the heart was so great as to displace and compress both lungs. The cysts may be single or multiple; in one case eighty were found forming a grape-like cluster extending from the right auricle into the ventricle through the tricuspid orifice. As a rule the hydatid develops within the wall, but it may occasionally project as a pedunculated cyst into the heart cavity or into the pericardial sac. In both cases the origin of the cyst is in the myocardium, but as the hydatid increases in size the muscle is either pushed aside or becomes atrophic, and may finally disappear, the cyst then coming to project either upon the pericardial or upon the endocardial surface. The pedicle consists of a portion of the overlying pericardium or endocardium. In rare cases the cyst may extend entirely through the wall, forming a fluctuating tumor covered on one side by pericardium and on the other by endocardium. The large hydatids may contain numerous daughter cysts, varying in size from a pea to a pigeon's egg. The heart muscle in the immediate neighborhood of the cyst may show no changes or the muscle fibers may be atrophic. The thickness of the cyst wall varies from one to five millimeters, but this may be much increased by fibroid changes in the overlying peri- or endocardium.

Small hydatids of the myocardium not projecting into the pericardial sac or heart cavity produce no symptoms and are usually discovered only at autopsy. When the cyst projects into the cavity of the pericardium, pericarditis may be produced, and this may in turn give rise to a pleuritis by direct extension. Subpericardial hydatids, however, do not always excite pericarditis. In neither case are the symptoms characteristic. Hydatids projecting into the heart cavity are very likely to rupture. In this event sudden death may result from the embolism of the daughter cysts in the pulmonary artery and branches. In the great majority of cases the perforation is into the right heart, the cysts blocking either the tricuspid orifice or the pulmonary artery. Smaller cysts may pass through the main pulmonary branches and lead to embolism of the smaller arteries and the formation of multiple hydatids throughout the lung. Death may result in such cases from pneumonia, slowly developing pleuritis, general cachexia, etc. Partial obstruction of the pulmonary orifices may give rise to symptoms of pulmonary stenosis and insufficiency. Rupture of an echinococcus cyst into the left heart may lead to blocking of the aortic orifice with resulting stenosis and insufficiency, or smaller cysts may cause occlusion of peripheral arteries, leading to local gangrenous conditions. In one case rupture occurred into both the right and the left heart. Embolism of echinococcus cysts in the right heart or pulmonary vessels may also occur as the result of the rupture of primary hydatids into the large veins. This occurs most frequently in the case of liver hydatids.

The differential diagnosis of heart hydatids is in the majority of cases impossible. The condition may be suspected when hydatids are present in other parts of the body, or from the nature of the emboli when embolism occurs. In one of the reported cases, in which there were numerous metastases throughout the lung, small cysts were found in the sputum. Aspiration of the pericardial sac and microscopical examination of the fluid thus obtained may lead to the recognition of the condition. In those cases in which the cysts do not rupture or project into the pericardial sac the symptoms are of a very indefinite nature and may suggest either myocarditis or valvular lesions. The treatment is entirely symptomatic. In certain cases surgical interference may be of avail. Goodhart claimed to have cured a case of hydatid cyst of the cardiac wall.

The cysticercus cellulosæ is of rare occurrence in the heart, only about thirty cases having been reported. The left ventricle appears to be most frequently affected. The cysts are usually few in number, the size varying from a bean to a hazelnut, rarely larger. They may be found in the muscle or just beneath the endo- or pericardium. As in the case of the echinococcus hydatids they may project from the endocardial surface into the blood stream, being attached to the wall by a slender pedicle formed by the endocardium. The layer of endocardium over the cyst may become very much thickened. The condition cannot be diagnosed during life, the symptoms being of a very indefinite character or entirely wanting.

Trichina spiralis is stated by many writers never to occur in heart muscle, but cases of such occurrence have been observed by Leuckart, van Zenker, and Fiedler. Pentastoma denticulatum has also been found in the heart wall. In the case of both of these parasites the affection of the heart is of pathological interest only. Aldred Scott Warthin.

Heart, Development of the.—The vertebrate heart arises in two distinct ways, each of which is intimately associated with the origin of the blood-vessels in general. In the lower vertebrates its first appearance is in the form of a single tube on the ventral median line of the embryo, quite near the head. Fig. 3061 is a section of a salamander embryo in which the heart is just beginning to form. The body cavity, *lh*, is composed of two lateral halves (see *Cœlom*) separated from each other by a median septum. It is in this septum that the heart first makes its appearance. The two layers which contain this septum become separated, and the opening soon becomes lined with a layer of cells, *end*, the endocardium. The cells of the septum surrounding the opening give rise to the muscle walls of the heart.

In higher vertebrates the heart is first formed by the union of two tubes arising from what may be called the outside of the body. Fig. 3062 is a surface view of a young rabbit embryo in which the heart is beginning to form on either side of the body. The omphalomesenteric veins on either side run toward the ventral median line, and later on unite. Their appearance is such, however, that before they are united they may be spoken of as two hearts. Fig. 3063 is from a section through an embryo of the same stage as that pictured in Fig. 3062. The neural canal, *nf*, is just beginning to close, and in the splanchnopleure on either side

there is a large fold, *ahh*, which already contains the endothelial tube coming from the omphalomesenteric vein. The tubes grow toward the median lines, but before they unite each has its descending aorta, as shown in Fig. 3064. The rudimentary hearts are formed between the splanchnopleure and endoderm, and as the former surrounds the heart to form its muscular layer the heart protrudes into the celomic cavity (Fig. 3063), much as does the single heart of lower vertebrates (Fig. 3061). Soon the two halves unite as indicated in Fig. 3064, and then we have a single heart with two veins entering from behind and two arteries, aortæ, leaving from in front. Although this primary division has nothing whatever to do with the later separation of the heart into its two halves, yet before the two primary hearts are united into a single tube the position of the ventricle is already marked (Fig. 3064, *h*). So to sum up, in the lower vertebrates the heart appears as a single tube which in general remains such during the life of the animal, and it must be viewed as the primitive form of heart. Higher in the animal scale the heart arises before the foregut is formed, from that portion of the splanchnopleure which later on lies in the median line of the embryo. It is this part which is to give rise to the heart, and in the higher animals the heart arises before the lateral parts have reached the median line (Hertwig). The two

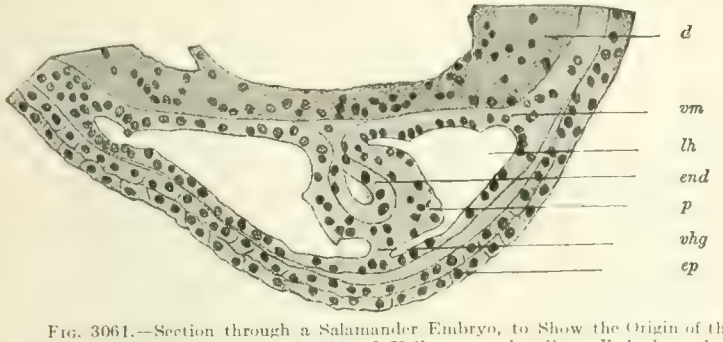

Fig. 3061.—Section through a Salamander Embryo, to Show the Origin of the Heart. (From Hertwig, after Rabl.) *d*, Yolk; *vm*, pericardium; *lh*, body cavity; *end*, endocardium; *p*, muscle layer of the heart; *ep*, epidermis.

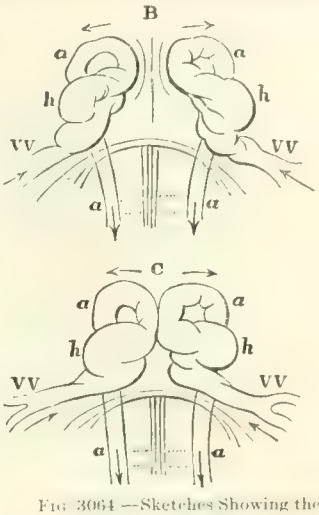

Fig. 3064.—Sketches Showing the more Advanced Condition of the Bitubular Heart of the Rabbit. × 22 times. (After Allen Thompson.) *C* is more advanced than *B*. *VV*, omphalomesenteric veins; *h*, heart; *a*, aorta; the arrows indicate the direction of the circulation.

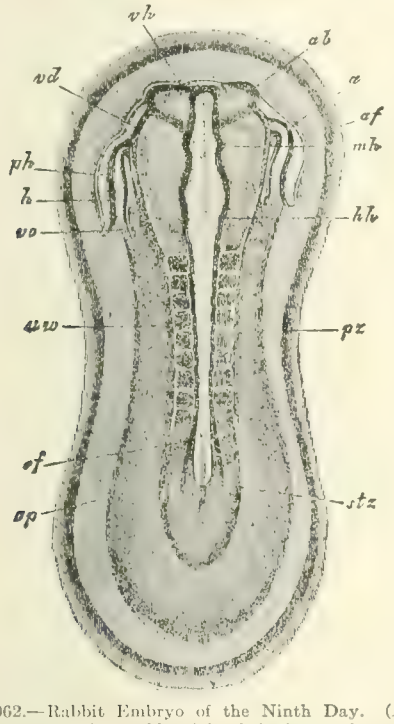

Fig. 3062.—Rabbit Embryo of the Ninth Day. (After von Kölliker.) × 10. *h*, Double origin of the heart; *ah*, optic vesicle; *vh*, forebrain; *mh*, midbrain; *hh*, hindbrain; *rf*, medullary groove; *ww*, myotomes; *h*, heart; *vo*, vena omphalomesenterica.

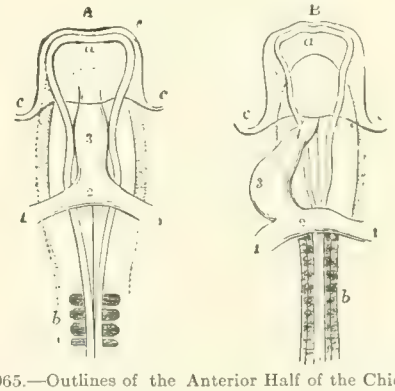

Fig. 3065.—Outlines of the Anterior Half of the Chick Viewed from the Ventral Side, Showing the Heart in its Earlier Stages of Development. × 20 times. (From Quain, after Remak.) *A*, Thirty hours; *B*, forty hours; *a*, anterior cerebral vesicle; *b*, myotomes; *c*, cephalic fold; 1, omphalomesenteric veins; 2, 3, 4, the heart.

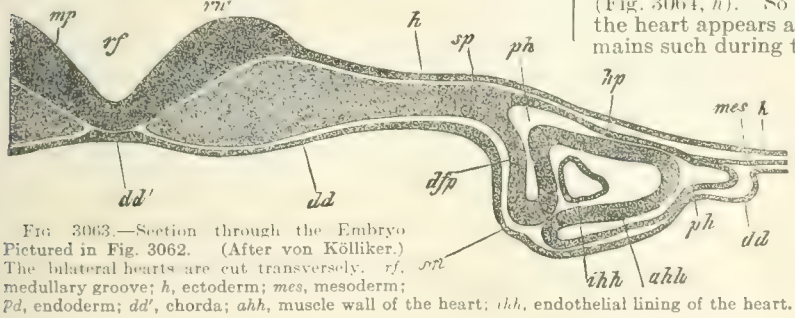

Fig. 3063.—Section through the Embryo Pictured in Fig. 3062. (After von Kölliker.) The bilateral hearts are cut transversely. *rf*, medullary groove; *h*, ectoderm; *mes*, mesoderm; *pd*, endoderm; *dd'*, chorda; *ahh*, muscle wall of the heart; *ihh*, endothelial lining of the heart.

hearts then unite into a straight tube which is destined to become separated into the right and left hearts of the adult.

Fig. 3065 is a ventral view of two chicks just after transverse septum and opening the body cavities. The entrance of the veins still lies behind, and the aorta in front, but the heart has already formed one complete loop, making of it an S. Fig. 3067 is a profile of the same embryo, and the heart is indicated as a cast of its cavity. It shows the variations in

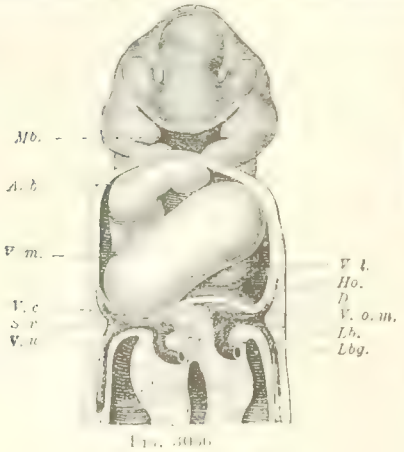

Fig. 3065

Fig. 3070.

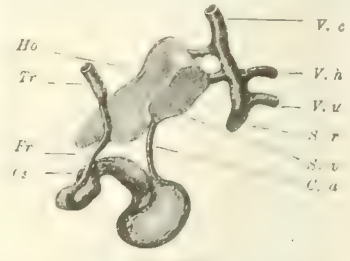

Fig. 3071

Figs. 3070 and 3071.—Ventral and Profile Reconstruction of His' Embryo, B. × 40 times. *Ho*, Auricle; *C. a*, atrioventricular canal; *Tr*, aorta.

caliber of the tube throughout its length. At a somewhat later stage the heart is bent upon itself more, and its walls have also become thickened. Figs. 3068 and

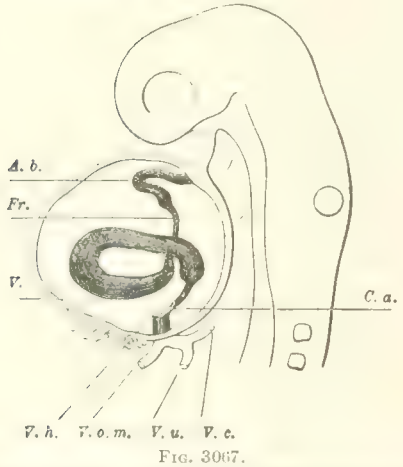

Fig. 3067.

Fig. 3066 and 3067.—Ventral and Profile Reconstructions of His' Human Embryo, Lg. × 40 times. (After His.) In the profile view only the outline of the cavity of the heart is shown. *V*, Ventricle; *A. b.*, bulbus aortæ.

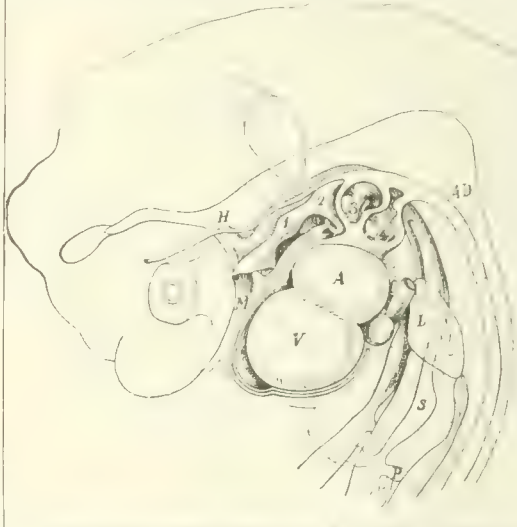

Fig. 3072.—Reconstruction of a Human Embryo enlarged sixteen times, and viewed from the left side. *H*, Hypophysis. 1, 2, 3, and 4, branchial pockets; *M*, mouth; *A*, auricle; *V*, ventricle; *AD*, descending aorta; *L*, lung; *S*, stomach. *P*, pancreas.

the two primary tubes of the heart have united. It is seen that the veins (1) enter from behind, but the relation is soon changed by the heart becoming bent as is already indicated in Fig. 3067.

Fig. 3066 shows the general form of the heart in a very young human embryo. The front of the thorax has been cut away, the incision also extending through the

Fig. 3068

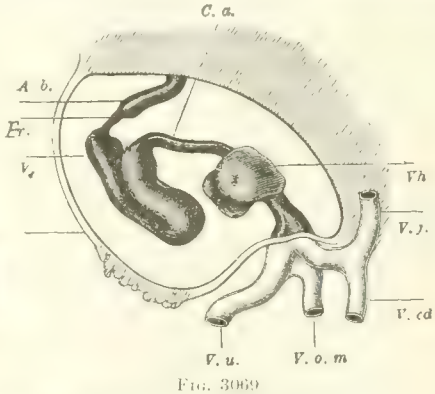

Fig. 3069

Figs. 3068 and 3069.—Ventral and Profile Reconstruction of His' Embryo, Lr. × 40 times. (After His.) *V*, Ventricle; *Vh*, auricle; *A b*, bulbus aortæ.

3069 are ventral and lateral views of a reconstruction at this stage. The profile view again gives a cast of the heart cavity, which now shows the beginning of the auricle (*V.h.*). At this time the heart is partly tilted over and the veins enter on the dorsal side. Viewed from in front, the auricles, which are just appearing, cannot be seen because they now lie on the dorsal side. A stage later (Fig. 3070), the adult form can already be recognized. The heart has undergone a half revolution and has reached the S form. The veins enter nearer the head and the artery arises behind, or away from the head. The aorta lies upon the ventral side and the auricles clasp it from the dorsal. Fig. 3071 shows the great irregularity of the cavity.

A profile view of a heart of this

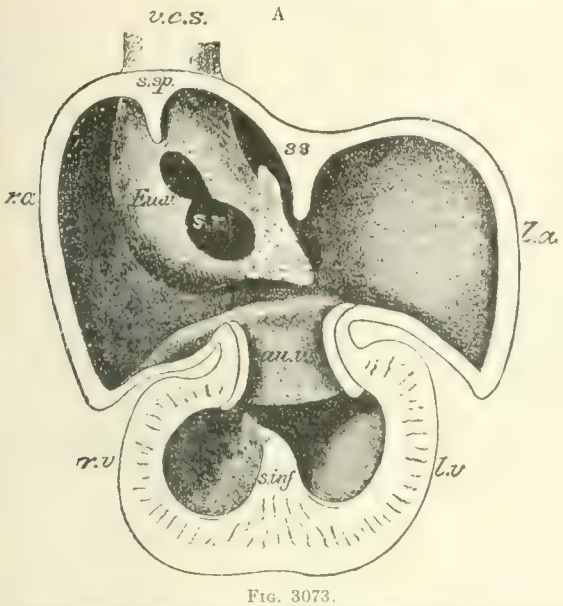

Fig. 3073.

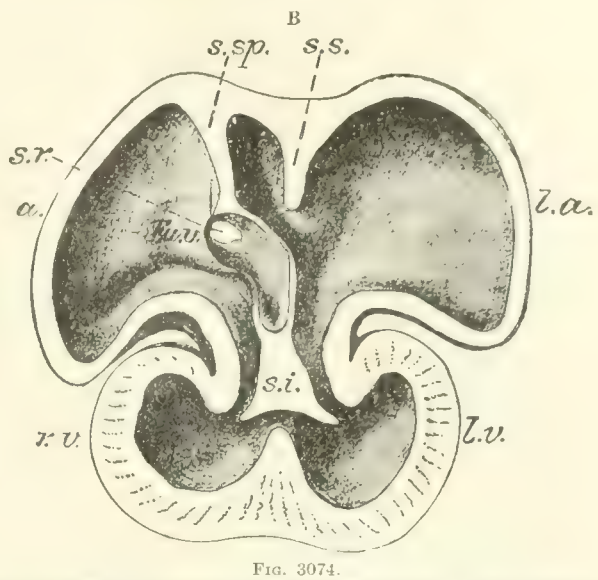

Fig. 3074.

Figs. 3073 and 3074.—Two Stages in the Formation of the Septum Intermedium in the Heart of the Human Embryo. (From Quain, after His.) In Fig. 3073, the septum is represented as growing from a triangular area to the left of the sino-atrial orifice; in Fig. 3074, it has coalesced with the endocardial cushions, and lies like a stopper in the atrial canal. *r.a.* and *l.a.*, right and left auricle (atrium); *r.v* and *l.v.*, right and left ventricle; *s.v.*, sinus reuniens *Eu.v.*, Eustachian valve; *s.sp.*, septum spurium; *s.s.*, septum superior; *s.inf.*, septum inferior; *s.i.*, septum intermedium; *v.c.s.*, vena cava superior dextra.

stage is shown in Fig. 3072, which shows the relation of the heart to the surrounding organs. The auricle (*A*) is now in front and the ventricle (*V*) behind. The larger veins enter on the dorsal side by one common opening into the right side of the auricle, the future right auricle.

After the heart has once reached this stage it is only to be separated into its right and left tubes to produce the mammalian heart. In some of the lower animals this never takes place, and in others it is only partial. In cases of arrested development the human heart in

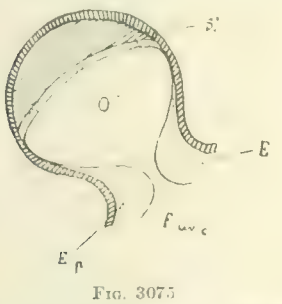

Fig. 3075.

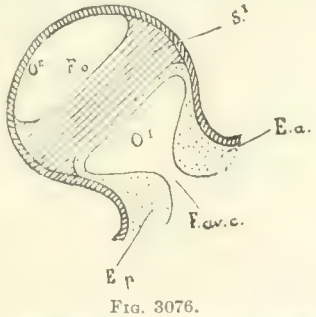

Fig. 3076.

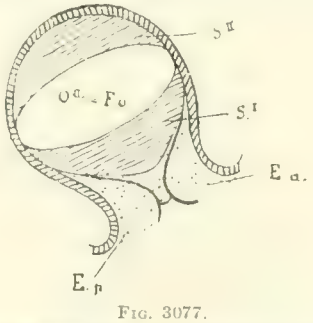

Fig. 3077.

Figs. 3075, 3076 and 3077.—Side View of Three Stages, to Show the Formation of the Foramen Ovale (After Born.) *S'*, First portion of the superior septum; *S''*, second portion of the superior septum; *O'*, first foramen ovale; *O''*, secondary opening or true foramen ovale; *E.p.*, endothelial cushion in the atrioventricular opening.

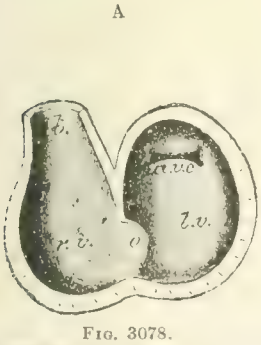

Fig. 3078.

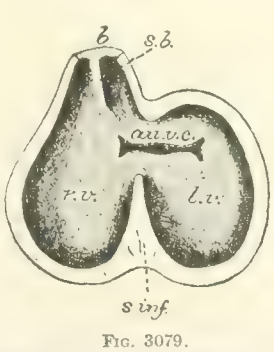

Fig. 3079.

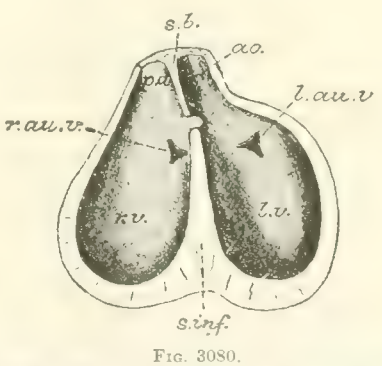

Fig. 3080.

Figs. 3078, 3079, and 3080.—Diagrams to Show the Formation of the Septum of the Ventricles and Bulb, and the Mode of Division of the Common Atrioventricular Aperture. From Quain, after Born. *r.v.*, and *l.v.*, right and left ventricles; *s.inf.*, inferior septum; *b.*, bulb of aorta; *s.b.*, septum bulbi; *au.v.c.*, atrioventricular canal; *ao.*, aorta; *pa.*, pulmonary artery.

the adult may show any of its embryological forms, as, for instance, an open foramen ovale.

Figs. 3073 and 3074 show the interior of two stages of early human hearts, taken from models made by His. In Fig. 3073, the auricle is enlarged and the vein enters on the right side. The ventricle is considerably

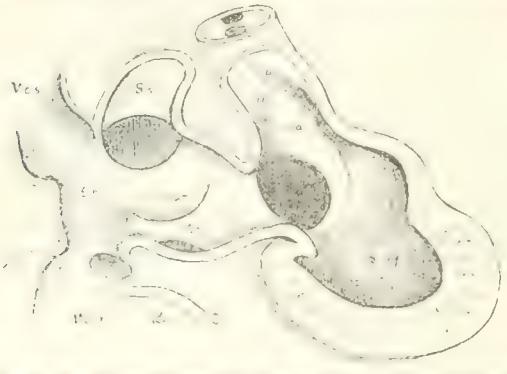

Fig. 3081.—Opened Heart of a Human Embryo Seen in Profile. × 33 times. (After His.) *p*, Pulmonary artery; *a*, aorta; *S.a.*, septum aorticum; *S.inf.*, septum inferior; *S.i.*, septum intermedium; *S.s.*, septum superior; *S.int.*, septum intermedium; *v.e.*, Eustachian valve; *S.r.*, sinus reuniens; *V.c.i.*, vena cava inferior; *Lb.*, liver; *D*, diaphragm.

smaller and its walls are much thicker than those of the auricle. This is usually the case with the hearts of embryos, as they die with the ventricles contracted and the auricles filled with blood. Between the two there is a narrowed auriculoventricular canal and with a corresponding constriction on the outside of the heart. Fig. 3074 shows a more advanced stage. The general state of the heart is much as it is in the Fig. 3073, only that the atria are "shoved" into the ventricle. This is of considerable importance, as we shall see later on. In both cases the aorta arises from the right side of the ventricle, and in its further development one-half of it must be transferred to the left side in order to produce the aorta proper, while the half which remains becomes the pulmonary artery.

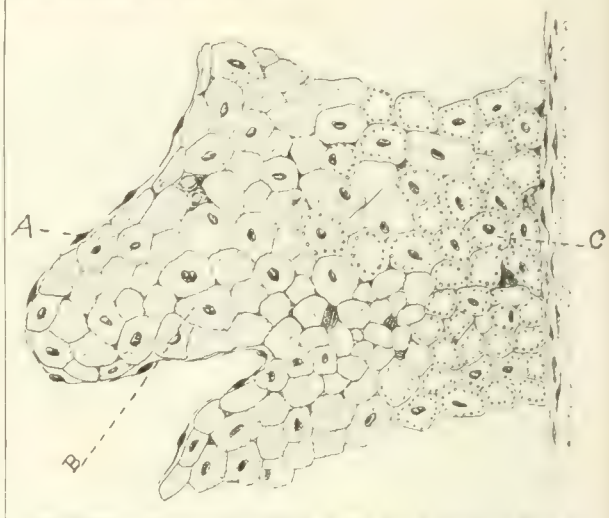

Fig. 3083.—Section of the Wall of the Heart Ventricle from an Embryo Pig 12 mm. Long. (After MacCallum.) The left side of the figure represents the inside of the heart. *A*, Endocardium covering a papillary muscle; *B*, cross-section of cells containing a simple network, and therefore very young; *C*, older cells containing fibril bundles.

The first important change in the separation of the heart into its two lobes is the formation of two septa, one arising in the atrium, *S.s.*, which grows backward, and one in the ventricle, *S.inf.*, which grows forward. At the same time that these are growing toward each other, a cushion of connective tissue, *s.i.*, is formed upon the two lips of the slit-like atrioventricular

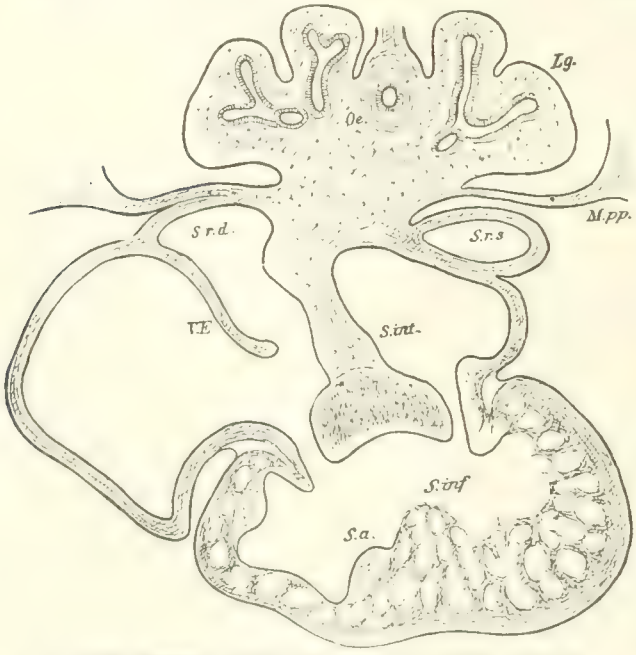

Fig. 3082.—Section through the Heart of a Human Embryo to Show the Formation of the Columnæ Carneæ. × 36 times. (After His.) *O.e.*, esophagus; *Lg.*, lung; *M.pp.*, membrana pleuropericardiaca; *S.r.d.* and *S.r.s.*, right and left horns of the sinus reuniens; *V.E.*, Eustachian valve; *S.int.*, septum intermedium; *S.inf.*, septum inferior; *S.a.*, septum aorticum.

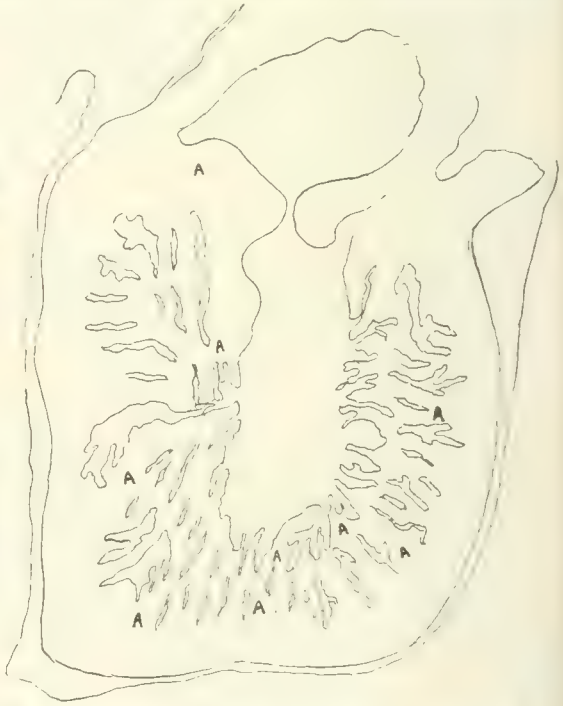

Fig. 3084.—Longitudinal Section of a Heart Ventricle from an Embryo Pig 16 mm. Long. (After MacCallum.) *A*, Position of karyokinetic figures.

opening which aids to complete the septum of the heart. This cushion, or septum intermedium, soon separates the atrioventricular opening into two canals, the right and the left, to become the right and left atrio-ventricular canals, respectively.

The septum of the atrium is completed by the septum superior growing backward to unite with the septum intermedium. Before this takes place, however, several changes take place in the septum (Figs. 3075, 3076, and 3077). These figures represent three stages of a lateral view of the two septa above named, with the opening between them. In Fig. 3075, the septum superior is forming, but the S. intermedium is not yet complete. It was at first thought that the opening between them, *O'*, produced the foramen ovale, but later observations by Born showed that there is a secondary rupture in the septum superior which is destined to become the true foramen ovale (Fig. 3076, *O''*). The portion of the septum superior which has been cut off by the formation of the foramen ovale, unites with the septum intermedium as shown in Fig. 3076. The secondary septum, *S''*, later on forms the limbus of Vieussens, and the first, *S*, the valve of the foramen ovale.

A partial septum of the heart is first met with in certain classes of ganoid fishes (Dipnoi), where it arises by a union of muscle columns in the auricle. This is a very incomplete septum, which is gradually increased in the amphibia. In neither of these cases has the septum reached the atrioventricular opening. This gives us an auricle partly divided, both compartments communicating with each other, and through a common opening with a single ventricle, much as is shown in the heart of the human embryo pictured in Fig. 3073. In the reptiles the septum is complete, and we have two distinct atria communicating independently with the ventricle. We can view this as the completion of the second stage, *i.e.* a complete union of the septum superior and the septum intermedium. In birds and mammals, however, there is a secondary rupture of the septum of the auricle; in the former it is multiple, and in the latter, as a rule, single. It is therefore seen that the formation of a secondary or true foramen ovale, as described by Born, is confirmed by the comparative anatomical evidence (see Born, *Arch. f. mik. Anat.*, Bd. xxxiii., and Röse, *Morph. Jahrbuch*, Bd., xv. and xvi.).

The opening of the vein is guarded by two folds of the walls of the heart, which really form a complete bicuspid valve (Fig. 3074). An addition fold extends to this from in front, the septum spurium, *S.sp.* Later on, the orifice enlarges to incorporate a portion of the veins into the auricle, but the right lip of the opening remains permanently as the Eustachian valve. The pulmonary veins are formed later. They grow from the lungs to the left auricle.

Returning to a stage of heart as represented in Fig. 3074, we notice that the common ventricle shows a constriction on the outside which corresponds to a septum forming on the inside. As this septum from

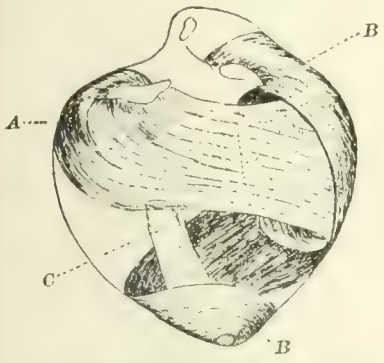

Fig. 3085.—Diagram of the Course of the Superficial Muscle Layers Originating in the Right and Left Atrioventricular Rings and in the Posterior Half of the Tendon of the Conus. (After MacCallum.) *C*, Anterior papillary muscle.

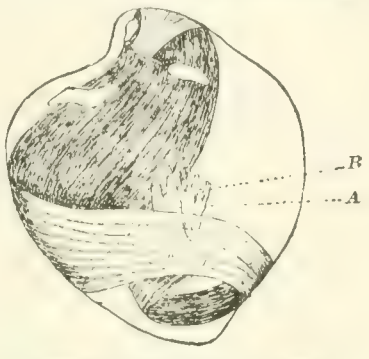

Fig. 3086.—Diagram of the Course of the Superficial Muscle Layers Originating in the Anterior Half of the Tendon of the Conus. (After MacCallum.) *A*, Posterior papillary muscle; *B*, papillary muscle of the septum.

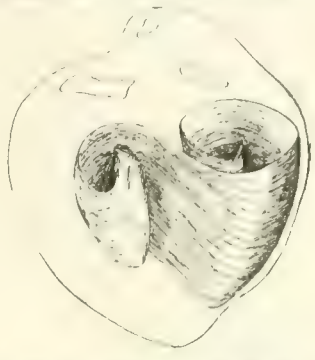

Fig. 3087.—Diagram of the Course of the Deepest Layer of Muscle of the Left Ventricle. (After MacCallum.) *A*, Posterior papillary muscle.

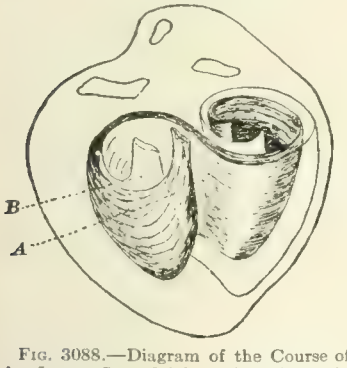

Fig. 3088.—Diagram of the Course of the Layer Superficial to that shown in Fig. 3087. The outline of the deep layer is also shown. (After MacCallum.) *A*, Posterior papillary muscle; *B*, papillary muscle of the septum.

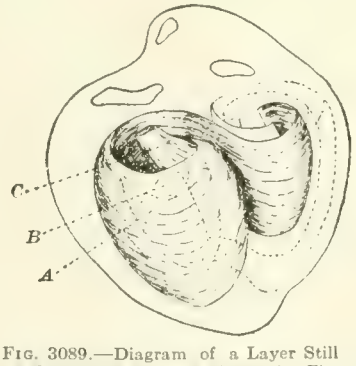

Fig. 3089.—Diagram of a Layer Still more Superficial to that Shown in Fig. 3088, and Ending in the Anterior Papillary Muscle. The other layers are represented in dotted lines. (After MacCallum.) *A*, Posterior papillary muscle; *B*, papillary muscle of septum; *C*, anterior papillary muscle.

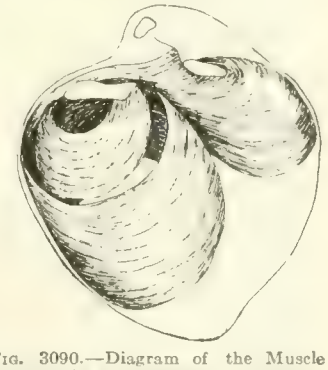

Fig. 3090.—Diagram of the Muscle Originating in the Tendon of the Conus and upper Part of the Right Ventricle. (After MacCallum.) This layer surrounds the layers represented in the left ventricle in Figs. 3087, 3088, and 3089.

the inside, the septum inferius, grows toward the septum intermedium, it must also grow toward the aorta to join a septum aorticum which is forming there. Figs. 3078–3080, show how this is brought about. Fig. 3078 represents a stage in which the atria empty wholly on the left side and the aorta arises wholly on the right. As the inferior septum arises the atrioventricular opening moves, as it were, toward the aorta; and when the septum inferius unites with the S. intermedium it cuts the atrioventricular opening in such a manner that the blood coming from the right auricle passes to the right ventricle, and the blood from the left auricle to the left ventricle. A small opening exists for quite a while between the two ventricles, but, later on, this is closed by a membrane of connective tissue. Before the ventricles are completely separated from each other, a view of the septum appears much as is shown in Fig. 3081. The aorta is already completely separated into two vessels: the one which communicates with the right ventricle, communicating above with the fifth aortic arch, and the one from the left with the fourth. The fourth is destined to become the aorta, and the fifth the ductus arteriosus from which the pulmonary artery arises.

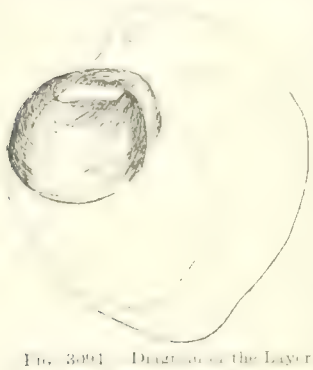

Fig. 3091. Diagram of the Layer of Muscle Surrounding the Aorta, and Left Atrioventricular Ring. (After MacCallum.) Fig. 3090 is represented in dotted lines.

At an early stage the tissue of the ventricle walls becomes spongy on the inside. These meshes and columns play a very important part in the formation of the valves, muscle columns, and the tendons to the valves. We have seen that the septum intermedium is formed in the atrioventricular canal and divides it into a right and a left half. When this is complete a section of the heart gives a picture as shown in Fig. 3082. At the same time a portion of the auricle is, as it were, pushed into the ventricle, as the figure shows. This invagination takes with it a portion of the epicardium, to be incorporated in the formation of the valve. Connective tissue is incorporated in the formation of the valve at its beginning, although the great bulk of the valve is at this time composed of muscular fibers. The burrowing of the ventricle walls includes also the valves, and in this way, as the figure indicates, the primitive chordæ tendineæ are formed. Soon, however, the bands lose their muscle fibers, in the portions which form the chordæ, and in other portions, farther away from the valve, the muscle fibers increase to form the papillary muscle. The valves have therefore a double origin: (1) Peripheral, and (2) from the septum intermedium. According to His, the tendons attached to the valves arising from the periphery, have their permanent attachment to the valve from the beginning, while a portion of those passing to the valve and arising from the septum intermedium may possibly shift their valvular attachment.

The muscle walls of the two ventricles are at first of the same thickness, but, later on, that of the left becomes heavier than that of the right. The spongy layer in the ventricle is covered with endocardium, and from this layer the columnæ carneæ arise.

MacCallum has made extensive studies on the development of the heart muscle cells as well as of the arrangement of the fiber bundles in the hearts of embryos. MacCallum has found that the heart muscle cell in its development undergoes certain changes by which younger and newly developed cells can be distinguished from fully developed cells. The difference between the older and younger cells is well shown in Fig. 3085, taken from the heart of a very young pig's embryo. It is seen that the younger cells are immediately under the endocardium and that the older cells have been pushed toward the outside and lie immediately below the pericardium. In the younger cells the nuclei multiply by indirect cell division and the distribution of such cells is shown by the letter *A* in Fig. 3084. Here again the growing point of the muscle of the heart is found to be immediately below the endocardium. It appears then that the growth of the heart after the organ is well formed is on the inside immediately below the endocardium. In some way, not yet definitely known, the heart is then gradually rolled up, becoming more and more complex in the higher animals. MacCallum has succeeded in unravelling the musculature in the embryo pig and the human fetus before the fibers have become interlaced too much. According to him, the fiber bundles can be divided into four groups: (1) Those arising from the auriculoventricular ring on one side and passing to the papillary muscle of the opposite side (Figs. 3085 and 3086); (2) those bundles arising from the papillary muscles on one side and passing to the papillary muscles on the opposite side (Figs. 3087, 3088, and 3089); (3) those fibers arising from the atrioventricular ring on one side and passing to the atrioventricular ring of the opposite side (Fig. 3090); and (4) those fibers which simply encircle the left atrioventricular ring and the aorta (Fig. 3091).

According to MacCallum, the points to be emphasized in his work are as follows:

The heart consists of several layers of muscle, the course of which is shown in some detail in Figs. 3085–3091. Nearly all begin in the atrioventricular ring of one ventricle and end in the papillary muscle of the other. Those fibers which begin near the outside of one ventricle end near the inside of the other ventricle.

The thin superficial muscle being removed, the left ventricle can be unrolled so that its cavity and papillary muscle are exposed. This shows it to be a flat band of muscle continuous with the muscle fibers which cross over in the septum from the right ventricle.

Grouping these layers together, it is plain that the heart in the embryo is a scroll-shaped band of muscle with tendons at each end. As it grows older the layer of muscle passing over in the septum from the right to the left ventricle remains comparatively thin, while the ventricular cells increase greatly in thickness. The place of most active cell growth is near the inside of the ventricular walls, and they are, therefore, at the two ends of the band of muscles making up the heart.

The above study deals essentially with the vertebrate heart, necessarily including the human organ. Of late years the latter *per se* has received much special study (see articles by author in the *American Journal of Anatomy*, 1911 and 1912, and Tandler's contribution in the Keibel-Mall Handbuch d. Entwicklungsgeschichte d. Menschen, 1911, vol. ii). It cannot be claimed, however, that any considerable additions to our knowledge of the human heart have accrued. A number of embryos have been studied and illustrated. The chief subjects of advanced study are: (1) Subdivisions of the primary heart tube. It is apparent that even in the same stage of embryonal development, there is a wide difference in embryonal hearts. (2) Formation of atrioventricular valves. In an embryo 11 mm. long it was possible to distinguish all the adult valvular connections. (3) The atrioventricular bundle. The fate of this temporary structure seems to be still unsettled. It is seen in embryos 8 mm. long, persists as a portion of the atrial canal, then becomes a part of the cardiac musculature, and stands in some definite relationship with the Purkinje system. (4) Musculature of left ventricle. Serial sections alone throw no light on this structure. Staining, studies by trans-

mitted and reflected light in various fluids, etc., must be added. The original circular fibers of the heart tube remain circular near the mouths of the vessels, but at the apex there is marked deviation. The ventricle, growing downward, is formed chiefly of spiral groups, the bulbospiral and sinospiral.

FRANKLIN P. MALL.

Heart, Dilatation of the.—*Definition.*—Dilatation of the heart may be defined as an increase in the cubical capacity of one or more of the cardiac chambers, resulting from a pathological cause. It is not generally realized that every increase in the cubical capacity of the heart is not necessarily abnormal. Thus, as a result of sudden muscular effort, the cavities of the heart may enlarge. This is the response of the organ to the increased call upon it, is compensatory, and physiological. How this differs from true dilatation will be explained more at length in the sequel. Dilatation may affect one chamber or one side of the heart, but, wherever it may originate, the condition frequently becomes generalized. *Partial* and *complete* forms may, therefore, be recognized.

ETIOLOGY. It is safe to say that dilatation never occurs in a healthy intact organ. Many cases are associated with and supervene upon hypertrophy of the heart. In fact, most of the causes that produce hypertrophy are competent to produce dilatation in time. The most frequent cause of simple dilatation is degeneration of the heart muscle, either cloudy or fatty, such as may occur in any of the infective fevers, typhoid, diphtheria, or pneumonia; in alcoholism and pernicious anemia; in chloroform poisoning. Then, dilatation not uncommonly develops in cases where there has been prolonged or repeated rapid action of the heart, as in Graves' disease and in paroxysmal tachycardia. Excessive muscular strain, either sudden or prolonged, or repeated, as in races or military campaigning, is a noteworthy cause. Muscular strain may also be caused by valvular incompetence or adhesion of the pericardium. The dilatation of the heart so often found in those who consume large quantities of beer daily is possibly in large part the result of plethora, but damage to the muscle cannot be excluded.

Acute myocarditis, such as may occur in scarlatina typhus, typhoid, and rheumatic fever, may result in dilatation.

Lastly, some few cases arise without determinable cause. Such have been attributed, possibly without reason, to worry, neurasthenia, and cold bathing. Having enumerated the various conditions under which dilatation of the heart may arise, we pass on to consider in some detail the rationale of the process.

PHYSIOLOGY AND PATHOLOGY.—Given a healthy heart, the condition of its muscle in large measure is directly dependent on the amount of work it has to do. Regarding it purely as a machine, the work performed by the heart in a given time is the resultant of the amount of blood propelled in that time and the peripheral resistance against which it is discharged. Further, the amount propelled may be estimated by multiplying the quantity discharged at each beat by the number of beats during the stated period. Therefore, the pressure being the same in both cases, a rapidly acting heart pumping a small amount of blood at each systole, and a heart beating at half the rate, and discharging double the quantity, will be performing the same amount of work. This bald statement, however, does not tell the whole truth. It is evident that the condition of things within the ventricles may be very different in the two cases. In the slowly acting heart, the diastolic expansion, in a general way, is twice as great as in the case of the rapidly acting heart and the muscle has to contract against twice the load. While, again, it is true that the amount of work done is the same in the two cases cited, the cost of production, to use an economic phrase, is far from being the same. A rapidly acting heart is always working at a disadvantage. The coronary circulation in the muscle is less effective, the nutrition suffers, and stimulus production comes so fast, that exhaustion is apt to follow. In other words, the reserve capital is encroached upon to a greater extent.

What happens when the heart is working against an increased resistance, as, for example, when there is an abnormal obstruction to the outflow of the blood from the organ, will be better apprehended if we refer to the well-known experiment in physiology with the gastrocnemius muscle of the frog. The laws governing the contraction of voluntary muscle may in all probability be applied to the case of the heart. If a series of graduated weights be applied to this muscle when at rest, it is found that some weights are so trifling that the length of the muscle is not increased. In other words, the natural tonus of the muscle is greater than the extending force applied. As the weights attached are progressively increased, the muscle becomes more and more elongated, at first somewhat quickly, later, as the limit of elasticity is reached, with less evident change. Applying this to the ventricular muscle, we see that increase in load, even within normal limits, leads to a natural distention of the cavity. To put it otherwise, increased work of the heart, within normal limits, is followed by enlargement of the heart in diastole. We must, therefore, distinguish between a natural, *physiological*, distention, and an abnormal, *pathological*, dilatation.

Furthermore, returning again to the experiment with the gastrocnemius, if we stimulate the muscle with a given strength of electrical current, and estimate the work done (*i.e.* the weight raised multiplied by the height to which it is raised) when a gradually increasing load is attached to the muscle, we find that the amount of work accomplished is by no means the greatest in the case of the smallest load. In fact, there is a certain optimum load, which with a given muscle and a given stimulus produces the greatest amount of work. We may infer in the case of the heart that there is also a certain definite load, which leads to its performing the greatest amount of work. It would seem, too, that a certain amount of distension of the ventricular cavity would result in more effective contractions, that is to say, the propulsion of a greater amount of blood during each systole. An old experiment of Roy and Adami will also serve to elucidate this question still further. If two points be taken upon the surface of the exposed ventricle in the dog, and the distance between these two points be accurately recorded under various conditions, it can be shown that, if one increase the interventricular pressure as by constricting the aortic arch, the heart becomes more filled during diastole, and the two points become farther apart. Again, during systole the points do not approximate to nearly such an extent as where there is less resistance. The same thing occurs if the heart is given more work to do by increasing the amount of blood supplied to it. With the increased work of the heart, there is with distention in diastole distention in systole also, that is to say, the fibers do not shorten to the same extent as in the heart working under ordinary resistance. There is, necessarily, therefore, residual blood in the chambers of the heart. The importance of this will be more readily understood if we regard the ventricular chambers as a sphere. As a sphere expands its cubical contents increase, not in an arithmetical ratio, but in such a way that if the circumference be taken as abscissæ, the contents as ordinates, the curve of values is what is called a cubical parabola. A degree of shortening of the cardiac fibers enough to reduce the circumference of the ventricle one inch, for example, will lead to a greater diminution in volume, and, therefore, a greater output of blood, the more distended the ventricle is at the commencement of its contraction. Thus, in the case

of a sphere ten inches in circumference, a diminution of its circumference by one inch produces a diminution of volume or an output equal to 4.5 cubic inches. On the other hand, in the case of a sphere five inches in circumference, a diminution of one inch causes an output of only 1.027 cubic inches, although in the first instance the circumference was reduced only one-tenth, and in the second, one-fifth. Therefore, with moderate distention of the heart the fibers have only to contract to a very small extent to expel a given amount of blood as compared with their contraction in an ordinary undilated heart. It would seem probable, therefore, that when the heart is hard pushed a certain amount of distention makes for economy, and that the presence of residual blood by lessening the extent to which each fiber is called upon to contract may be a saving to the heart and through it to the organism as a whole. It follows from all this, that hypertrophy is never primary but is always preceded by distention. The truth of this may be illustrated by what takes place in the heart of athletes under training and during races. During a race, of course, the work of the heart is for the time being greatly increased. It has to beat quicker and more forcibly to supply the necessary amount of blood to the muscles. The first effect of this is to increase the peripheral blood pressure. Later, with the establishment of "second wind" the strain on the left heart is relieved by the dilatation of the peripheral blood-vessels and consequent reduction in the blood pressure. It is common to observe after a race an enlargement of the cardiac dullness, which can only be attributed to acute distention of the ventricles, as it usually promptly subsides on resting. This distention is, apparently, a necessary accompaniment of increased cardiac strain. Repeated strains, such as occur in the course of athletic "training", lead to enlargement of the heart, which persists so long as athletics are indulged in and for a variable period afterward. This is in the main the result of hypertrophy of the cardiac muscle, but there can be little doubt that the heart of the athlete is not only more muscular but more capacious than is that of the untrained individual. The question now arises, How are we to distinguish between distention of the type we have just been discussing and true dilatation? Various answers have been given. One is that normal or physiological distention is temporary, while pathological dilatation is permanent, but there are sufficient exceptions to the general truth of this statement to render it a misleading conception. I would prefer to put the answer in this way. The distention of the athlete's heart, and of conditions analogous to it, is the response to increased demands upon the organ. It is at once adaptive and protective. Such a heart is strong, capable, and effective. The pathologically dilated heart is the reverse of all this. It is not the result of a demand for more work. It is a weak, laboring, and ineffective heart. To put the whole matter in a nutshell, it is merely a question of reserve power. In the former case the functional capacity of the heart is ample, the reserve is not seriously encroached upon. In the latter, the reserve power is so diminished that the slightest extra call leads to disability.

As the matter has been stated just above, it may be inferred that the problems involved in the pathogenesis of the two conditions distention and dilatation are quite different. And, indeed, this is the case, though this is a view that has not as yet obtained current acceptance. The conception of the average practitioner on this subject may not be unfairly stated thus. Hypertrophy of the heart is due to an effort on its part to overcome increased peripheral resistance, which increased peripheral resistance is evidenced by a heightened blood pressure. This connotes the idea that there is a force acting within the chambers of the heart which tends to force their walls outward. For a time the heart can cope with the situation through the increase in its musculature. Hypertrophy is in excess. Later, as the strain increases and the heart muscle becomes inadequate to meet the increased demand upon it, hypertrophy gives way to dilatation. It is indeed surprising that a view so obviously illogical and absurd should have passed current for so many years. It is only one more evidence of the power of tradition and blind faith even in matters scientific. A moment's reflection, one would think, would have served to show its inaccuracy. The pressure within the ventricles is produced by the cardiac systole itself, acting against a system of elastic peripheral vessels. In the final analysis, the strain upon the ventricular walls is due to the systole only, for the elastic recoil of the arteries is taken up and nullified, so far as the heart is concerned, by the semilunar valves. An increased intraventricular pressure is the result of a muscular contraction more powerful than normal, and no one would seriously put forward the opinion that in the process of contraction dilatation is produced. Contrariwise, if the heart muscle is weakened, systole is less powerful and the intraventricular pressure is diminished. With a failing heart muscle the distending force is therefore less apparent. Nor can dilatation be the result of a distending force operating during diastole. It is now commonly taught that the diastolic relaxation is an active matter. The heart is a suction pump as well as a force pump. The amount of blood within the cardiac chambers during diastole is directly dependent on the degree of muscular relaxation and a positive pressure can only be produced by the initiation of systole. There are, practically, only two conditions in which dilatation of a chamber could be produced by an increase of intracardiac pressure. In insufficiency of the mitral or tricuspid orifice the powerfully contracting left or right ventricle, by driving a column of blood backward into the less muscular auricle, would lead to dilatation of the latter chamber. Similarly, in the case of aortic regurgitation, the left ventricle will be overdistended by the increased influx of blood into it. blood derived on the one hand from the left auricle and, on the other, from the peripheral vessels, the latter blood being returned with some force owing to the elastic recoil of the arteries. Apart from this, there is abundant evidence for concluding that neither the resistance opposed to the cardiac muscle during the contraction of its chambers, nor any distending force operating during diastole is sufficient to bring about dilatation. For example, hearts with degenerated muscle and thinned walls may continue to work against a high peripheral tension and yet may never show dilatation. Such hearts, may, in fact, rupture from extreme wasting of the fibers without any evidence of dilatation. Again, conversely, a chamber may become dilated when the distending force of the blood entering it is even less than normal, as in the case of the left ventricle in some instances of mitral stenosis. Evidently, there is some other cause for cardiac dilatation than mechanical pressure. This cause is to be found in depression of tonicity. *Dilatation of the heart is the anatomical expression of the lack of tone of its contracting fibers.*

Pathogenesis.—Tonus is one of the properties of all muscle, voluntary and involuntary, and the laws which govern muscle in general may very properly be applied to the case of the heart. When we consider the various conditions of disease under which dilatation of the heart may occur, we find that they may be grouped into two main classes, those which are associated with grave degeneration of the muscular fibers, and those producing muscular overstrain. Now, since tonus is that property of muscle whereby its fibers are maintained in a position short of complete relaxation, it is not surprising that conditions like cloudy swelling, hydropic and fatty degeneration, should invite relaxation, not only by interfering

mechanically with the contraction of the fibers, but also in some cases by producing a loss of muscle substance. Overaction, by exhausting the contractile function, tends to the same result. The few cases of cardiac dilatation in which no very definite cause can be traced, may, I would suggest, be attributed to a disturbance of innervation of the cardiac muscle. It is well known that if the neurotrophic supply of a muscle or group of muscles be cut off, flaccidity or loss of tone will result. Examples of this may be seen in the affected muscles of hemiplegics, in postneuritic atrophies, and in poliomyelitis. The hypertrophies of overwork may, also, it is well known, give place to atrophy and loss of tone. It is not unlikely, indeed, that in the majority of cases a number of causes cooperate to bring about a condition of malnutrition of the cardiac muscle as well as of the trophic nerves. The heart is dependent for its nourishment mainly upon the coronary vessels, and if great hypertrophy exists the blood supply may eventually become insufficient, with the result that degeneration sets in. Not infrequently, also, the very conditions that induce cardiac hypertrophy, such as aortic insufficiency, arteriosclerosis, lead to this result directly by causing obstruction to the coronary circulation, thus bringing about cardiac anemia. When the dilatation has reached such a degree as to cause relaxation of the aortic, mitral, or tricuspid rings, the reflux of blood under a greater pressure than the chamber chiefly concerned has been accustomed to support leads in its turn to dilatation of that cavity and bad is made worse. A vicious circle results and hastens the fatal termination.

Morbid Anatomy.—The appearance of the dilated heart after death is very characteristic. One or more chambers are more capacious than they should be; the right ventricle more often than the left; the left auricle more often than the right. In the case of mitral stenosis the left auricle and the whole right heart are commonly involved. Not infrequently, the heart as a whole manifests the change. The heart wall may be thickened (excentric hypertrophy) or thinned (simple dilatation). In appearance the muscle is pale, flabby, often cloudy or fatty. The columnæ carneæ and trabeculæ are flattened and atrophic; the chordæ tendineæ are thinned and elongated; the mitral and tricuspid orifices are often enlarged, and their accompanying valves show evidences of regurgitation. Where one-half of the heart is more affected than the other, the septum is apt to encroach upon the less involved side. With this there may be evidences of gross organic change in the heart or its valves, endocarditis, coronary sclerosis, myomalacia, fibroid degeneration. Myomalacia, or localized infarctous change in the cardiac muscle may lead to a circumscribed bulging or pocketing of the wall, usually a part of the left ventricle (so-called cardiac aneurysm).

With all the signs detailed above, there are those which are the manifestation of cardiac failure; edema of the lungs, passive congestion of the viscera, anasarca, plethora.

Symptoms and Physical Signs.—With a dilated heart the muscular contractions are weak, and its propulsive power is, consequently, inefficient. However the condition may have supervened, whether primarily or as an end-result of preexisting myocardial or endocardial lesions, its subjective and objective manifestations are practically those of ruptured compensation. In other words, the reserve power of the heart is so encroached upon that the organ is no longer able to respond perfectly to ordinary every-day calls made upon it. The main symptom, so far as the patient himself is concerned, is dyspnea. The person so affected finds that he is unable to perform some action, which he was formerly able to manage with ease, such as climbing a hill, without getting out of breath. As the condition progresses, the disability increases, until he is unable to perform the simplest action without discomfort. Even turning over in bed may finally precipitate an attack of breathlessness. In aggravated cases the patient may start out of sleep with a sense of suffocation; he is compelled to sit up (orthopnea) and gasp for breath (so-called "cardiac asthma"). Eventually, even the slightest emotion may provoke an attack, and the condition may become continuous. Pain is not usually a prominent feature, but it is not uncommon to find patients complaining of vague discomfort over the precordium. Hyperalgesia of the skin, breast, and deeper tissues of the left side of the thorax, or, occasionally, of the left sternomastoid and trapezius muscles, may be observed.

The objective symptoms, or physical signs, may be grouped into those due to alterations in the size, shape, and position of the heart, alteration in its movements, and associated conditions due to failure of the circulation in the periphery of the body and in distant organs, such as anasarca, cyanosis, enlargement of the liver, diminution in the output of urine, and albuminuria.

One proof of the existence of a dilated heart is found in increase in the cardiac dullness. This sign is rarely absent except in cases where the heart is covered over by expanded lung, as in emphysema. It is, however, a difficult matter in many instances to decide just what part any cavity may play in the dilatation, owing to the fact that the heart not only enlarges in dilatation but rotates. This phenomenon is due to the fixation of the heart at the base by the great vessels. Enlargement, notably of the right ventricle, leads to displacement of the whole organ to the left and the encroachment of the right side upon the front, the left side finally disappearing behind. Enlargement of the cardiac dullness to the right of the sternum may be safely put down to enlargement of the right side, particularly of the right auricle, but is never so great as the actual enlargement of the right heart would lead one to suppose. Before diagnosing enlargement of the right heart from this sign we should exclude aneurysm, intrathoracic tumor, and left-sided pleural effusion.

Careful percussion of the heart should be carried out to determine its outlines. In dilatation the greatest enlargement is transverse and there is very little increase in the vertical dullness. Dullness may, however, be occasionally found as high as the second interspace. The shape of the dull area is more rounded, as compared with the triangular area, with the apex uppermost, of pericardial effusion.

The cardiac impulse is diffuse, of wide amplitude, often wavy. A point of maximum intensity may not be made out. When the left heart is pushed over to the left and backward, the true apex impulse may not be felt. In such cases, such impact as may be detected may be due to some portion of the right ventricle. The chief impulse may be below or to the right of the ensiform cartilage and there may be an undulatory movement in the fourth, fifth, and sixth interspaces to the left of the sternum. In cases of great dilatation of the right auricle there may be observed a pulsation in the third right interspace near the sternum. Occasionally, a pulsation in the left second interspace, systolic or presystolic in time, possibly due to an enlarged right auricle, may be detected.

The first sound is shorter, sharper, and more like the second, a condition known as embryocardia. As dilatation increases, it becomes weaker and may disappear. The long pause is shortened. Not infrequently reduplication of the first sound is to be heard, as also gallop rhythm. There may be no murmurs, or murmurs may be present, due to the great dilatation with relative insufficiency of a valve or to actual endocarditis. The pulse is small, quick, often irregular.

So long as the contractile power of the heart can maintain a sufficient blood pressure to supply the needs of the various tissues, the heart weakness is manifested only by those subjective symptoms dependent on reduction of reserve force. While the patient is at rest, that is to say, makes no special call upon this reserve force, he may be tolerably comfortable. The slightest exertion, or even worry alone, will, however, cause distress. When the blood pressure sinks to the extent that the peripheral structures are no longer sufficiently nourished, then the grosser phenomena, anasarca, ascites, hydrothorax, congested organs, and marked cyanosis, make their appearance.

Edema of the soft tissues is frequently the first objective sign of cardiac insufficiency and may come on with great rapidity. In those who are walking about it appears about the ankles first; in those who are confined to bed, over the sacrum. It increases in extent and intensity until effusion occurs into the peritoneal cavity and the pleural sacs. Edema of the lungs is a sign of capital importance. Careful auscultation will often reveal its presence even before anasarca becomes manifest. With commencing heart failure a few fine crackling râles may be heard at the bases of the lungs at the end of deep inspiration. With one or two respiratory movements they may disappear, but as cardiac weakness increases become permanent. Later still, there may be impairment of the resonance over the bases of the lungs, amounting in some cases to complete dullness, with enfeeblement of the breath sounds. This indicates hypostatic congestion and even consolidation of the lung substance.

Coincidently with the appearance of dropsy, the urine is diminished in amount, becomes high-colored, more concentrated, and often contains albumin and a few casts. The character of the urine is a valuable indication of the patient's physical condition. As the case improves, the dropsy lessens, and the excretion of urine is increased. The albumin will disappear, unless there is associated with the cardiac condition a true Bright's disease. This is often a difficult matter to decide. The course of the case will often aid in forming a correct opinion. Arterial sclerosis and retinitis, for example, would, if present, strengthen the case for a coexisting chronic nephritis. These urinary phenomena, when not due to nephritis, are the result of passive congestion of the kidneys.

Enlargement of the liver is also a manifestation of venous stasis. Associated with this may be a moderate degree of jaundice. The enlarged organ is often extremely tender and there may be spontaneous pain in the right hypochondrium. Mackenzie states that it may not be present in the earlier stages of cardiac failure, but when once it has occurred, every subsequent attack suffices to induce it, even before dropsy sets in.

Diagnosis.—The diagnosis of dilatation of the heart is usually easy. The enlargement of the cardiac outline, the weak fluttering impulse, the feeble irregular pulse, and the signs of deficient reserve power, are the cardinal and characteristic features. Some difficulty may arise when it is impossible for various reasons to accurately outline the heart by percussion, as in cases of obesity, emphysema of the lungs, pericardial and pleural effusions. From hypertrophy which gives a very similar area of increased cardiac dullness, dilatation may be distinguished by the fact that, in hypertrophy the impulse of the heart is strong and heaving, giving the suggestion of weight and power to the examining hand. The hypertrophied heart is a strong heart, consequently, the pulse is full and strong, often of increased tension, and signs of cardiac insufficiency are conspicuous by their absence. The cardiac sounds here are loud and resonant, the first often booming, while in dilatation the first sound is short and sharp, often faint, resembling a normal sound.

In emphysema of the lungs, so often associated with arteriosclerosis, the heart, notably the right side, not infrequently becomes dilated in time. The character of the pulse, the enfeeblement of the pulmonary second sound, and the appearance of moist crepitations at the base of the lungs will afford the clue here.

Pericarditis with effusion might possibly be confused with dilatation owing to the notable increase in the cardiac dullness in both affections. Pericarditis, however, is accompanied by fever, there may be a friction rub, the apex of the heart is dislocated upward, and there is a characteristic outline, the dullness extending upward considerably and assuming a pear shape. The pulsus paradoxus may also be present in pericarditis. Dilatation may of course be associated with pericardial effusion, and is a not infrequent concomitant of this condition, but it is not often possible to diagnose it by physical examination. At most, one may hazard a shrewd guess. The mechanical effect of the pressure of fluid upon the outer surface of the heart will hamper its action as effectively as will dilatation and will lead to the same manifestations of cardiac insufficiency. The development of murmurs under observation does not serve to clarify the picture, for they may be due to acute endocarditis, which so frequently accompanies pericarditis.

Where a pleural effusion is sufficiently extensive as to merge with and obscure the cardiac dullness, we can only be guided by the course of events. Should a heart which has previously been acting strongly and regularly become suddenly weak and irregular, with alteration of its sounds, or should gallop rhythm suddenly set in one may suspect dilatation.

In all cases, the signs of dilatation become unequivocal, when under observation the heart's outline suddenlye nlarges, the pulse previously firm and steady become feeble and erratic, and the signs of loss of compensation begin to show themselves. The recognition of acute dilatation is particularly important, inasmuch as appropriate and energetic measures must be taken promptly in many cases if the patient's life is to be saved.

Prognosis.—The degree of cardiac tone present in any given case is of cardinal importance in estimating the nature of cardiac failure. Yet, we must be cautious in giving a prognosis based upon the amount of dilatation alone. Great dilatation may be quite compatible with a favorable outlook, while a much less marked dilatation may be an indication of considerable gravity. The test comes in the patient's own response. If, with a dilated heart, he gets along with ease and comfort, it is an indication that the cardiac muscle is otherwise intact and that the heart is able to cope with the disability due to the dilatation.

Another valuable prognostic feature is found in the way in which the heart responds to the exhibition of digitalis and similar drugs. The beneficial action of digitalis in heart affections is in large part due to its influence on cardiac tone. When, then, a heart that is dilated fails to respond satisfactorily to digitalis, the outlook becomes correspondingly more serious. Especially is this the case in those forms associated with marked arteriosclerosis.

Treatment.—Dilatation of the heart being practically never primary, treatment should be instituted always with reference to the underlying condition. Those cases occurring in the course of or as sequelæ to the acute infections must be treated on their merits. Prolonged rest in bed, suitable diet, attention to the general well-being of the patient, must be insisted upon. In diphtheria the timely and judicious use of antitoxin will do much to forestall the occurrence of dilatation. Where dilatation supervenes during the febrile stage of an acute illness, drugs are of little value. There is some little difference of opinion as to the usefulness of digitalis in these cases. Some phy-

sicians use it but, personally, I have never observed any positive benefit from it. Probably, the best line of treatment is to save the heart from all unnecessary strain, eliminate the offending toxins, and support the patient's strength. Later, if the condition improves, graduated exercises, to increase the heart's vigor, will be in order.

Those cases due to anemia should be treated by iron, arsenic, and tonics generally.

Dilatation coming on acutely, and evidenced by gallop rhythm, urgent dyspnea, and lividity, is best combatted by venesection. The timely abstraction of twenty to thirty ounces of blood, according to circumstances, may save life. At the same time one should exhibit digitalis or strophanthus in some of their more active and readily absorbed forms. The tincture of digitalis and the infusion are too slow in their action to be relied on in an emergency. The intramuscular injection of 1 c. c. of digalen, repeated as necessary, gives very prompt results. In extremely urgent cases, the intravenous injection of strophanthin (one one-hundred and twentieth of a grain) should be the procedure of choice. The dose may be repeated, if required, in an hour. Care should be exercised where the patient has been taking digitalis previously, lest a sudden cumulative and dangerous effect be produced. In cases where, owing to circumstances, absorption from the alimentary tract is likely to be deficient, it is well to continue the use of strophanthin or digalen intramuscularly, rather than to give these drugs by the mouth. Digitalis and its congeners are extremely valuable in the treatment of dilatation, inasmuch as they markedly improve muscular tonicity, which is the function chiefly at fault. Secondarily, by thus improving the propulsive force of the heart and slowing its action they promote its nutrition and render the general circulation more effective. The dilatation occurring in connection with chronic valvular lesions, notably in rheumatic hearts, is particularly amenable to the action of digitalis. Even in aortic insufficiency, where, theoretically, this drug is contraindicated, it should be tried. So long, and only so long, as dilatation is in excess should it be exhibited, and in many cases a certain amount of benefit will be derived.

While, however, we should treat energetically the condition of dilatation itself, basing our practice on scientific principles, the associated and resultant conditions call frequently for amelioration. Dropsy and diminution in the excretion of urine call for digitalis. The promotion of diuresis is, in my opinion, the most satisfactory form of treatment. The old-fashioned Guy's pill (one grain each of powdered digitalis leaves, squill, and blue mass) often works like magic. Under its influence I have seen an enormous ascites disappear within a week, with concomitant improvement in the pulse, respiration, and the patient's general condition. When digitalis fails, diuretin may succeed. Failing this, theocin-sodium acetate should be tried. It sometimes works extremely well. Attention should be directed to keeping the bowels well emptied. Occasionally, when drugs are unavailing, a change of posture, as, say, a return to bed, may be sufficient to reestablish the activity of the kidneys. The French school of physicians has pointed out that retention of the chlorides in the tissue is often associated with edema. There can be no doubt that a judicious restriction of the intake of the chlorides in the food, notably in the particular of common salt, will hasten the disappearance of a dropsy.

Anasarca, if not too extreme, may be benefited by massage, but it should be gentle. Swollen legs may be bandaged. Effusion of any size into the abdominal or pleural cavities may often be tapped with propriety and great comfort to the sufferer. This may need to be repeated. In extreme cases of edema of the legs, blisters may form, and, as the circulation is poor and the resisting power of the tissues low, great care must be taken to prevent infection. I have even seen gangrene of the skin supervene in these cases. This danger of infection is the great objection to the employment of multiple incisions or the insertion of Southey's tubes, which some advocate, though doubtless a large amount of fluid may be eliminated by these measures.

As the case improves and the heart's action becomes stronger, the dropsy may entirely pass away. Only a certain amount of edema of the lungs may remain. Here, breathing exercises, judiciously employed, will be of great benefit. The patient should sit upright and breathe slowly and deeply. At first this should only be attempted for a few minutes but if well tolerated the time should be cautiously increased until the exercises can be carried out every two or three hours during the day.

Dyspnea will be benefited by the employment of the measures already detailed, but when extreme and distressing should be treated by morphine hypodermically. This drug frequently is the only thing to give relief. It should be used cautiously should much pulmonary edema or bronchitis exist.

ALBERT GEORGE NICHOLLS.

Heart, Displacements of the.—Before one can arrive at a clear understanding of the subject of displacements of the heart it is necessary first to determine what is the normal position of that organ within the thorax; then, what are the factors which may exert a propelling force upon it; and finally, what controls the direction of its movement.

The position and outlines of the heart cannot always be accurately mapped out by percussion, and the most exact information is to be obtained by observations in suitable cases on the cadaver, and, above all, from carefully prepared skiagrams. The heart occupies the middle mediastinum and, in a general way, may be said to lie in the central portion of the thorax, close behind the sternum, about two-thirds of the organ being to the left of the median line of the body. The upper border, composed of the two auricles and the roots of the great vessels, reaches as high as the second intercostal space. The right border, consisting almost entirely of right auricle, can be indicated by a curved line drawn with its convexity to the right, beginning at a point slightly above the junction of the right third rib with the sternum and ending at the junction of the seventh rib with the sternum. The maximum degree of curvature is found at a point about one inch to the right of the right edge of the sternum. The lower border, chiefly right ventricle, passes from the seventh right costosternal junction to the apex, a variable point, usually, however, in the fifth left intercostal space, one-half inch inside the nipple line. The left border, almost wholly left ventricle, runs from the apex to about the left third costochondral junction with the convexity of line to the left. The long axis of the heart is directed to the left, somewhat downward, and slightly forward. The portion of the heart to be viewed from the front is almost entirely the right side, there being only a small strip of the left ventricle and the tip of the left auricle at the extreme left. The right border reaches a point on an average 4.3 centimeters to the right of the mid-sternal line, and the left border, 8.9 centimeters to the left of it.

The above statements are true of the heart as in the majority of normal mature persons. Some slight deviations from this norm, of a physiological character, are occasionally met with. Thus, one of the most important landmarks, the apex is not infrequently found in children to be in the fourth interspace in the mamillary line or even outside of it. In the aged the apex may be in the sixth interspace. And, a certain amount of movement (from one to three centimeters) of the whole heart to right or left occurs when the individual reclines on the corresponding side. The

movements incident to respiration also result in certain trifling movements of the organ.

The pathological displacements of the heart are to be divided into two groups, the congenital and the acquired. The former are of so little practical importance that they may be dismissed with a word or two. In the condition known as complete transposition of the viscera the heart and stomach lie on the right side of the body and the liver on the left. Here the apex beat is in the right fifth interspace and the closure of the aortic valves is heard on the left side instead of on the right. Much rarer is the condition in which the heart only is reversed, the aorta being given off from the right ventricle and the pulmonary artery from the left. Occasionally, the heart is not situated within the thorax at all. Thus, it may be found high up in the neck—*ectopia cervicalis;* beneath the skin of the thorax, presenting through a cleft in the sternum—*ectopia thoracalis;* or it may enter the abdomen through a defect in the diaphragm —*ectopia abdominalis.*

It should be observed that the heart lies within a sac, the pericardium, which is anchored more or less firmly above to the great vessels of the circulation, below to the diaphragm, and anteriorly to the sternum by loose areolar tissue. The heart depends from the great vessels and its base, therefore, constitutes a relatively fixed point, while the apex is competent to roam more or less at large. The normal position of the organ is maintained also by the support afforded by neighboring structures, the sternum in front, the aorta, esophagus, and vertebral column behind, and the lungs to each side. From the nature of the case, therefore, displacements are more apt to take place laterally, and to be of wider excursion, than to occur in an anteroposterior direction. Owing to the fact, too, that the base is more fixed than the apex, movements of the heart are almost invariably compounded of a movement in a lateral or anteroposterior plane with a rotary one about an anteroposterior axis.

Etiology.—Displacement of the heart being entirely a mechanical affair is to be explained on mechanical principles. The direction of the movement tends to follow the line of least resistance. Final analysis will show that the line of progression and its extent is the resultant of the various forces brought to bear upon the heart, in the main, the motive force and the resisting force.

The motive power may be conveniently and sufficiently accurately regarded as including two orders of causes—those that exert *pressure*, and those that exert *traction* on the heart. In the first case the organ may be pushed out of place by fluid effusions in the pericardium or pleural cavities, pneumothorax, intrathoracic tumors, aneurysms, abscesses, emphysema of the lungs, pneumonia, scoliosis and kyphoscoliosis, atelectasis, flatulent distention of the stomach or bowels, a high state of the diaphragm, enlargement of the liver or spleen, subphrenic abscess, ascites, the pregnant uterus, obesity, tight lacing, abdominal tumors, and diaphragmatic hernia. In the second case, practically the only cause to be mentioned is cirrhotic contraction of the lung with adhesive pleurisy and mediastinopericarditis.

The resisting forces are (1) the cardiac attachments, notably the pericardium and the great vessels at the base; (2) the weight of the heart itself, and (3) the density and elasticity of neighboring structures.

The pericardial attachments are of such a character as to restrain to a considerable degree displacements of the heart as a whole, while interfering much less with the rotation of the organ upon its relatively fixed point, the base.

The weight of the heart is of but little practical importance. At most, in cases of hypertrophy, may it lead to an exaggeration of the normal displacement produced by the lateral decubitus.

The character of adjacent structures plays a greater rôle, more especially in limiting the extent of the movement and, to some extent, guiding its direction. Pleural, pleuropericardial, and mediastinopericardial adhesions, for example, may be of such a nature as greatly to limit a displacement which otherwise would be much greater. The bony thorax presents a notable barrier to the movement of the heart anteriorly or posteriorly. The interplay of these various factors leads to two orders of displacement, that of movement of the heart and middle mediastinum as a whole, and that of rotation. Not infrequently both are combined. Rotation is usually about the long axis of the heart, or a fixed point at the base.

Varieties of Displacement.—(1) The heart, pericardium, and great vessels, that is to say, the whole middle mediastinum may be abnormally movable in all directions—*cor mobile;* (2) displacement may take place laterally, to right or left; (3) upward; (4) downward; (5) anteriorly; (6) posteriorly. To take up these different forms in more detail:

1. *Movable heart* is more common in men than women, and is usually, though not invariably, associated with hepatoptosis. On posturing the patient, a lateral movability may be demonstrated, amounting to from four to seven centimeters. Generally, the cases are met with in those who are emaciated, probably because disappearance of the mediastinal and omental fat leads to an increased laxity of the attachments.

Lateral displacements are of the most frequent occurrence and of the most extreme degree. Right lateral displacement is more easily recognized than is the left lateral form. The apex being the most movable portion of the heart is disproportionately dislocated in these cases. In right lateral displacement the apex is depressed but never to the extent that it occupies a position external to the base. In left-sided displacement the apex is considerably elevated, so that the long axis of the heart is almost if not quite horizontal.

Left lateral displacement, which is the most common form, is produced by collections of fluid in the right pleural cavity, solid enlargements of the right lung or right lobe of the liver, tropical abscess of the liver, extensive subdiaphragmatic abscesses, and contraction of the left lung. Displacement to the right is due to left-sided pleural effusions, tumors of the left side of the chest, and fibroid contraction of the right lung.

Upward displacement in general is attributable to a high position of the diaphragm. This may be caused by obesity, flatulency, pregnancy, ascites, tight lacing, ovarian cysts, large fibroids of the uterus, pericardial effusion, and enlargement of the liver or spleen. Enlargement of the liver, from whatever cause, if of sufficient degree, will raise the heart upward and push it toward the left. A large spleen will force it upward and to the right. Pericarditis lifts the apex upward so that the long axis of the heart becomes more horizontal.

A *low position* of the heart (*bathycardia*) is most frequently due to a low position of the diaphragm, such as may be caused by hepatoptosis, a congenitally prolapsed liver, enteroptosis, and emphysema of the lungs. In all these cases the arch of the diaphragm is somewhat flattened. Occasionally, the condition is found in persons who have long flat chests. Here, although the diaphragm is low it is well arched. The downward movement of the heart is limited by the position of the diaphragm and the extensibility of the structures at the base of the heart. As a result of the elongation of the thoracic cavity the heart hangs free above the diaphragm (*hanging* or *dropping heart*).

From the nature of the case, *displacement forward* is somewhat uncommon and limited in degree. In young people, in whom the ribs are pliable and yielding, the heart may be pushed forward by tumors or

cysts of the posterior mediastinum. Cardiac hypertrophy may also lead to bulging of the precordium.

Backward displacement is usually associated with other forms of dislocation. In certain individuals the heart is normally placed more deeply than it is customary to find it.

Morbid Anatomy.—The conditions found postmortem naturally vary considerably with the etiological factor at work. In addition to the *causa causans*, pleural effusion, adhesions, tumor, aneurysm, or what not, the heart is found in an abnormal position or its axes are disturbed. The pericardium is stretched or, it may be, displaced bodily with the heart. Where the pericardium and heart have become adherent, and the former is attached to the pleura or body-wall, the heart may be firmly fixed in its abnormal situation. The great vessels at the base of the heart and at the root of the neck are pulled upon and twisted, according to the direction and degree of the cardiac displacement. This will induce structural changes in the vessel walls, and an obstruction to the onflow of blood which reacts upon the heart itself. Hypertrophy and dilatation of that organ are not uncommonly found. Compression of the cardiac walls, resulting in a notable disturbance of function, may be the most important finding.

Pathological Physiology.—Whether the function of the heart is greatly disturbed or not in cases of displacement depends mainly on the degree of integrity of the heart muscle. A healthy heart will be able to perform its duties sufficiently well even under the increased burden imposed by malposition. The circulation is often surprisingly little interfered with in cases where considerable pressure is exerted upon the heart, as in large pleural effusion. A suddenly exerted pressure is, of course, more detrimental than one gradually brought about. Nevertheless, it must be admitted that in all cases the reserve power of the organ is encroached upon. Where dislocation is considerable and continued for years, as we have seen in certain greatly deformed humpbacks, hypertrophy followed by dilatation and loss of compensation will eventually result. Where the heart muscle is diseased, as from fatty degeneration or fibrosis, or where the cavities are dilated, heart failure will set in sooner. Under such circumstances a suddenly exerted pressure may lead to alarming or even fatal syncope. Where gradual heart failure supervenes in cases of displacement its secondary results are similar to those found as a result of other causes.

Symptoms.—When dislocation is brought about gradually and is not excessive in degree, few or no symptoms of moment may result. If, however, the condition is suddenly induced, the displacement is extreme, or the heart is previously weak, great distress may result. There are precordial oppression, more or less pain of an anginoid character, palpitation, and respiratory difficulty. The face may be pale or cyanotic. Syncope and even death may result in cases of previously damaged hearts where compression is exerted suddenly. In stout or plethoric individuals, sudden gaseous distention of the stomach or bowels is particularly dangerous.

Physical Signs.—The most obvious signs of cardiac displacement are, alteration in the position of the cardiac dullness, and a change in the location and character of the apex beat. Owing to the fact that the apex is more freely movable than is the base, the point of maximum intensity of the first sound of the heart is usually much more displaced than that of the second. Where the heart is dragged out of position of adhesions, the area that should normally be occupied by cardiac dullness may be more or less resonant, owing to the encroachment of the opposite lung. Where, however, the heart is pushed over by a solid infiltration of lung or pleura, or by pleural fluid, the normal area of dullness remains dull. Displacement forward leads to an increase in the area of cardiac dullness, sometimes with bulging of the precordium; displacement backward causes a diminution. In upward dislocation the dullness may extend to a higher point than normal, while the apex is displaced upward and to the left. When the heart is in contact with a solid mass, as, for example, in cancer of the lung or pleura, the sounds are carried with considerable distinctness over the area of dullness. In pericardial effusion and in deep position of the heart the sounds are weak. In displacement to the right a systolic murmur may often be detected, attributable to kinking of the great vessels. In displacement downward the heart sounds are heard best in the epigastric region and over the left lower ribs. Should the heart be pushed forward or rotated in such a way that a greater proportion of its surface comes in contact with the thoracic wall, the area of pulsation may be greatly increased.

Diagnosis.—Diagnosis is usually easy. The most important points are: the change in position of the cardiac dullness, the appearance of pulsation in unusual places, the lack of apex beat in the proper site, the alteration of the cardiac sounds in situation and character. The condition is made more certain if an apparent displacement is found to progress in a definite direction from day to day. A careful observer can hardly mistake any other condition for cardiac displacement.

Prognosis.—Displacement of the heart in itself is rarely serious, save in the case where it is induced suddenly and the integrity of the heart is already compromised. Death may then result suddenly. As a rule the disability is of temporary duration and of trifling character. When the heart becomes fixed in an abnormal position the outlook is not so favorable as when it returns to its former place. Hypertrophy, dilatation, and eventually loss of compensation, may occur in aggravated cases. Displacements due to pleural or pericardial effusions are relatively favorable. Those due to intrathoracic growths are unfavorable. In general, it may be said that the prognosis depends largely on the gravity or otherwise of the inducing cause.

Treatment.—The treatment resolves itself into that of the primary cause. Should the heart be greatly displaced from the pressure of fluid, to the extent of causing marked dyspnea and palpitation, the fluid should be removed by aspiration. This should be done slowly and the whole amount should not be removed at one sitting. This procedure is indicated not only for the mitigation of the distress, but to prevent the possible fixation of the heart in an abnormal position. In the traction cases, and those due to malignant growths, there is nothing to be done. Displacements downward, when associated with visceroptosis, may be relieved by the application of a suitable abdominal supporter. A. G. Nicholls.

Heart, Endocarditis.—See *Endocarditis*.

Heart, Fatty Degeneration of the.—Fatty degeneration of the heart muscle is a retrograde change characterized by the presence of minute fat droplets within the muscle protoplasm. It is distinguished from fatty infiltration, in that in the latter process the fat is a labile fat deposited in connective-tissue cells, either beneath the pericardium or between the muscle fibers. The term *fatty heart* is often used as a designation for both fatty degeneration and infiltration, but it should be applied to the latter condition only. It should be emphasized that the essential difference between these two conditions is, that in fatty degeneration the fat is in the degenerating muscle cell, in part taken up from the blood and in part arising from the combined

invisible cell-parts; while in fatty infiltration the fat is in connective-tissue cells, deposited there from the blood. Normal hearts contain about 15.4 per cent. of lipins; in hearts that show fatty degeneration the amount is increased to about 20.7 per cent., showing that fat is taken up by the degenerating muscle from the blood. The fats in fatty degeneration of the myocardium are chiefly neutral fats.

Gross Appearances.—Severe degrees of fatty degeneration may exist without recognizable changes in the appearance of the heart. The naked-eye diagnosis of this condition is in many cases difficult and uncertain. When the process is extreme the heart muscle becomes diffusely cloudy, yellowish in color, and of softer consistence; it may have a fatty shine or give a fatty smear. The condition may be diffused or localized to certain areas. The latter form is the more readily diagnosed, inasmuch as the heart muscle so affected presents a peculiar mottling of red and yellow, occasionally disposed in the form of transverse stripes or broken bars, the so-called "tiger-heart." This appearance is best seen on the endocardial surface of the left ventricle, particularly in the papillary muscles. In the majority of cases the degeneration is most marked in the trabeculæ of the wall of the left ventricle near the apex; the septum, right ventricle and auricles being affected in degree according to the order given. In the left ventricle the papillary muscles and trabeculæ usually show the most severe change, and in some cases the process may be sharply localized to these, the yellowish color of the papillary muscles standing out in sharp contrast to the normal brownish-red of the remainder of the heart wall. The heart is usually increased in size without a corresponding increase of weight. Dilatation of greater or less degree occurs, and the organ as a whole is flabby, flattening when laid upon the table. On section into the muscle the color change may affect the wall uniformly throughout, but more often it is found in streaks and patches of varying form, size, and distribution. The discolored muscle is more opaque than normal, cloudy, easily torn, and gives a fatty smear to a warm knife. In very extreme cases the degeneration may be so severe in sharply outlined areas as to present an appearance closely resembling that of an abscess. It must be remembered that fatty degeneration of the heart muscle rarely exists alone, but is usually associated with cloudy swelling, atrophy, anemia, etc., all of which processes complicate the diagnosis from the gross appearances.

Microscopical Appearances.—The diagnosis of fatty degeneration in many cases can be made only on microscopical examination. This should always be done with the fresh tissue when possible, inasmuch as the processes of fixation and hardening often completely destroy the appearances of the degeneration by the removal of the fat-droplets and the contraction of the tissue. Fixation of the muscle in osmic acid or Flemming's solution will obviate this danger. Slight degrees of fatty change are, however, always best brought out by the treatment of freshly teased muscle with osmic acid or by staining with Sudan III or Scharlach R. The affected muscle fibers are found to contain minute fat-droplets arranged in rows between the masses of interfibrillary sarcoplasm, beginning about the nucleus and extending linearly toward the ends of the fibers. In the early stages the transverse striations are usually not affected, but in severe degrees of the change they gradually disappear, first at the fiber-ends and then toward the nuclei. The staining power of the nucleus is always affected; in extreme degrees the nuclei may be entirely lost. The changes are usually most marked in the fibers lying just beneath the endo- and pericardium, the endocardium itself being rarely affected. In the acute forms of fatty degeneration cloudy swelling, segmentation, and fragmentation, etc., are usually found in association with the fatty change; in the chronic cases atrophy of the fibers, both simple and pigment, with increase of the interstitial connective tissue, is present.

Etiology.—The causes of fatty degeneration of the heart are both local and general. Of the former disturbed nutrition resulting from sclerosis or obstruction of the coronary arteries is the most common and important cause. Fatty degeneration of the muscle may also be caused by disturbances of nutrition secondary to myocarditis, cardiac abscess, pericarditis, and endocarditis. In pericarditis the degeneration may be confined to the layer of muscle immediately beneath the epicardium.

The two great general causes of this degeneration are anemia and intoxication. It is of common occurrence in pernicious anemia, chlorosis, leukemia, and all forms of secondary anemia. It occurs after long-continued or frequently repeated hemorrhage (epistaxis, hemoptysis, hematemesis, menorrhagia, metrorrhagia, hemorrhage from the intestines, hematuria, etc.). It has been observed after venesection. Fatty degeneration is also commonly associated with the cachectic anemias, of chronic suppuration, chronic diarrheas, syphilis, tuberculosis, malaria, malignant growths, etc. In all of these conditions the systemic intoxication is to be regarded also as a possible factor in the production of the condition. Focal fatty degenerations of the heart muscle can be caused by the localization of colonies of *Spirocheta pallida* in the myocardium. As has been shown by the writer the parasites of syphilis may exist in the myocardium without producing other lesions than a fatty degeneration. Deficient oxygenation due to cardiac insufficiency, valvular lesions, emphysema, fibroid pneumonia, etc., also causes fatty change of the heart muscle. The relation of fatty degeneration to cardiac insufficiency is not entirely clear; the condition is almost always present in the failure of compensation of the hypertrophied heart in chronic valvular disease, and while it is usually regarded as being the cause it is also possible that it may be the result of the cardiac insufficiency.

Extreme fatty degeneration of the cardiac muscle occurs in poisoning with phosphorus, arsenic, antimony, chloroform, etc. It may also occur to an extensive degree in the acute infectious diseases, especially in typhus and typhoid fevers, recurrent fever, scarlet fever, diphtheria, pneumonia, puerperal fever, pyemia, etc. Elevation of the body temperature causes fatty degeneration of the heart muscle. In acute yellow atrophy of the liver and in puerperal eclampsia the fatty degeneration of the heart may be so marked as to resemble that seen in phosphorus poisoning. In the infectious diseases the fatty change is to be attributed chiefly to the action of the poisons produced in these conditions, but the effect of the increased temperature of the body must also be regarded as an important factor. Long-continued mercurial inunctions, iodoform and chloroform poisoning, morphinism, the camphor habit, the long-continued use of dilute mineral acids in beverages, or as adulterants of vinegar, mushroom poisoning, etc., are among the many other supposed factors of fatty degeneration of the myocardium. Cardiac dilatation associated with fatty degeneration of the myocardium is often the only cause of death found in patients who die after major surgical operations, particularly laparotomy. In the later stages of chronic nephritis and gout there is almost always present extensive fatty change in the heart, resulting partly from the general cachexia and anemia, and partly from sclerotic changes in the coronary vessels. The habitual use of alcohol is one of the most important causes of slowly progressive fatty degeneration of the myocardium. The condition is found particularly in the case of

habitual beer drinkers. The condition is of very frequent occurrence among the lower classes in Germany and Austria with whom beer forms a very important part of the daily diet. In France the use of dilute mineral acids in some of the beverages consumed by the lower classes is said to be an important factor in the production of fatty degeneration.

High living, over-eating, lack of exercise as well as excessive muscular activity are regarded as either primary or predisposing factors to cardiac degeneration. Idiopathic hypertrophy is practically always followed by fatty degeneration. Cardiac over-strain in laborers, athletes, etc., is another very important etiological factor. A slight amount of fatty change in the senile heart is to be regarded as physiological. The pathological fatty degeneration of the heart due to anemia or cachexia is found more frequently in women than in males; that due to coronary sclerosis, alcoholism, etc., much more frequently in males. The majority of the cases are in individuals past fifty years of age. Cardiac fatty degeneration occurring in young individuals is almost always due to intoxication or infection.

Medicolegal Importance.—The importance of fatty degeneration as a cause of death from acute cardiac dilatation has not been sufficiently recognized. A degeneration sufficient to cause death may be missed if the microscopic examination of the heart muscle is made only in fixed preparations. In all cases in which the cause of death is important the examination of the heart muscle in the fresh state should be carried out by teasing or frozen sections stained with the fat dyes.

Symptoms.—The symptoms of fatty degeneration do not differ from those of other forms of myocardial affections. It is usually impossible to differentiate between fatty and fibroid heart. The most extreme degrees of fatty degeneration, as found in severe cachexias, pernicious anemia, etc., may give rise to no symptoms if cardiac dilatation has not taken place. It is the latter condition which produces the symptoms which are usually associated with fatty degeneration. Dyspnea, cardiac irregularity, palpitation, precordial distress, vertigo, the so-called pseudo-apoplectic attacks, rapid and weak pulse, etc., are symptoms of dilatation rather than of fatty degeneration. Very rarely anginal attacks may occur without coronary changes. In the late stages Cheyne-Stokes breathing may be present. The physical signs are those of dilatation. Death may occur from sudden overstrain or from slowly developing cardiac insufficiency. In rare cases aneurysmal dilatation of the cardiac wall may result from local weakening of the myocardium due to fatty degeneration.

Prognosis.—In the majority of cases of myocardial disease the prognosis is very unfavorable, especially in the slowly developing or chronic form. Acute degeneration of mild degree caused by acute infections or poisoning may recover completely; the more severe forms may be very quickly fatal. Within certain limits chronic fatty change of mild degree does not quickly lead to a fatal issue.

Treatment.—The occurrence of fatty degeneration may be many times prevented by careful regulation of the daily life. In suspected cases strict diet should be enforced, the amount and character of muscular activity carefully planned, and the patient protected from excitement of all kinds. Sudden death during sexual intercourse, straining at stool, lifting, running, etc., is extremely common in this affection. Alcohol should be entirely withdrawn, and the amount of fluid limited. When the signs of dilatation have not appeared digitalis is usually not advisable. Strychnine and nitroglycerin may be given. When symptoms of cardiac insufficiency are present the treatment should be carried out along the lines indicated for the treatment of failure of compensation in chronic valvular disease.

Aldred Scott Warthin.

Heart, Fatty Infiltration of the.—Fatty infiltration (*adipositas cordis*) of the heart is that condition in which the subepicardial fat alone is greatly increased, or in connection with this increase there is also an extension of adipose tissue into the myocardium. Normally there should be but a small amount of subepicardial fat and this should be confined to the sulci and grooves along the superficial coronary vessels, being greatest in amount at the base of the heart and especially in the auriculo-ventricular groove, particularly upon the right side. Over the greater part of the ventricular surfaces in the active, muscular male of early adult life there should be no fat, but after the age of forty, there is a physiological increase in the amount of the cardiac panniculus. There are, however, wide individual variations in the amount of subepicardial fat within apparently normal limits, depending upon intrinsic peculiarities of metabolism, habits of life, etc. The presence of fat cells between the muscle fibers in the interstitial tissue of the myocardium is under all circumstances to be regarded as pathological. Such an encroachment upon the muscle is usually due to a direct extension of adipose tissue from the subepicardial fat, chiefly along the lines of the arterial branches. Secondary to the infiltration of adipose tissue there is an atrophy of the heart muscle. In extreme cases the greater part of the myocardium may be replaced by adipose tissue which may extend even to the endocardium. In some cases the deposit of fat in the cells of the interstitial tissue may be secondary to a primary atrophy or degeneration of the heart muscle, the formation of fatty tissue being of the nature of compensatory process (fatty infiltration *ex vacuo*). Two forms of fatty infiltration may therefore be distinguished clinically: primary and secondary fatty heart. Of these the first variety is by far the most common and important.

In extensive hyperplasia of the subepicardial panniculus the heart is usually increased in size, partly from increased thickness of its wall, and partly from dilatation. The weight of the organ may or may not be above that of the normal. The entire heart may be encased in a thick layer of fat (lipoma capsulare cordis, adipositas cordis, obesitas cordis, lipomatosis cordis, fatty overgrowth, etc.). The most extensive deposit is found at the base of the ventricles along the auriculo-ventricular groove, in some cases having a distinct lobular arrangement. The heart muscle may not be visible through the epicardium at any point. On section through the heart the layer of adipose tissue may be found to form almost the entire thickness of the wall, the muscle consisting of a thin layer beneath the endocardium. In the most extreme cases the fat may reach to the endocardium in the form of trabeculæ extending along the intermuscular septa, gradually diminishing in size as they approach the endocardium. On microscopical examination groups of fat cells are seen between the muscle fibers. The latter may show varying stages of simple or pigment atrophy. Fatty degeneration of the atrophic muscle is not infrequently present. Serous atrophy (edema) of the cardiac panniculus is very common in starvation, wasting diseases, cachexias and terminal infections. Following the rapid removal of the fat from the fat-cells the latter partly collapse and in part become distended with fluid (edema *ex vacuo*). The subepicardial panniculus in such cases loses its yellow color, becomes translucent and watery or mucoid in appearance.

Fatty infiltration of the heart may exist as a part of a general obesity, either congenital or acquired. Lack of exercise, overeating, excessive use of carbohydrates, alcohol, etc., as well as excessive water drinking are the most important factors in the production of this condition. It is most common in males at

middle age; in women it may exist as a part of general obesity associated with or following the menopause. Deficient oxygenation from anemia or from chronic pulmonary disease also leads frequently to fatty infiltration of the heart. The condition is often found in the cachexias of chronic tuberculosis, carcinoma, etc. It occurs in the early stage of diabetes, and in certain forms of chronic poisoning, drug habits, etc. (iodoform, morphine, camphor, chloroform, dilute mineral acids, etc.).

Symptoms.—A moderate degree of fatty infiltration may exist without signs or symptoms, but beyond a certain limit the overaccumulation of fat beneath the epicardium or its infiltration into the myocardium causes impairment of the cardiac function. In such cases the apex beat is lost, the cardiac impulse is very faint or not present at all, the area of dulness is increased, and the heart sounds are muffled. The pulse is soft, of low tension, often rapid and irregular. The affected individual is stout, with excessive abdominal panniculus, and usually shows signs of general venous congestion. Palpitation, precordial distress, and dyspnea are produced by slight exertion, and there is a tendency to excessive sweating. The symptoms are in large part those of a general obesity with a heart relatively too small. The urine is usually increased in amount, pale and of a low specific gravity. In an individual with general obesity these signs and symptoms may be taken as certain indications of fatty heart. In the cases of primary atrophy of the heart muscle with secondary fatty infiltration the differential diagnosis is not so easily made. In these cases the subcutaneous panniculus may be greatly decreased, and the cardiac symptoms obscured by those of the condition causing the myocardial atrophy. In the later stages of fatty infiltration the symptoms are those of cardiac dilatation, and the condition cannot be diagnosed from other forms of myocardial affections.

Prognosis.—The prognosis on the whole is much more favorable than in the case of fatty degeneration. In cases of acquired obesity due to manner of living it is quite good. In congenital obesity it is much less favorable, and when secondary to other disease processes the prognosis rests wholly upon that of the more serious condition. It must be emphasized that the individual with fatty heart cannot meet without danger many conditions involving slight degrees of heart-strain. Intercurrent affections such as influenza, bronchitis, pneumonia, typhoid fever, etc., are very likely to cause death through cardiac insufficiency. Dilatation of the right ventricle is not infrequent. Anesthesia (particularly chloroform), surgical operations, excessive fatigue, muscular strain, intense emotion, etc., are to be regarded as dangerous factors in the case of individuals affected with fatty infiltration. While sudden death is not infrequent in this condition it is not nearly so common as in the case of fatty degeneration.

Treatment.—In the cases associated with obesity the treatment is very simple and if carefully followed very successful. The administration of drugs is of secondary importance and is usually limited to general tonics and to the improvement of elimination. The essential factors of the treatment are entirely hygienic. The diet should be chiefly nitrogenous, fats and carbohydrates being reduced to the smallest possible proportions. The use of alcohol should be entirely stopped, and but little fluid should be taken with the meals. The quantity of food and drink taken should be most carefully regulated. The amount and character of physical exercise taken are of prime importance and should be most carefully prescribed. The use of certain mineral waters is of great value in many cases as a means of promoting elimination. Turkish baths may be employed toward the same end. In the forms of fatty infiltration due to anemia, etc., the treatment is carried out along lines depending upon the primary disease.

Aldrid Scott Warthin.

Heart, Functional Diagnosis and General Therapeutics of the. "There has seldom prevailed among scientific physicians such unanimity as is now seen in the demand and tendency to let medicine be pervaded with the spirit of physiology." These words, more true now than when they were written, are from the introduction to a thesis published in 1879 by Dr. Joseph Neisser of Schweidnitz, Germany. The title of the publication was "Physiological Diagnosis as a Basis for Rational Therapeutics." The conception suggested by this title was a brilliant one but it is only now after the lapse of many years that we are beginning to have the knowledge necessary to put it into practice, at least in so far as diseases of the heart are concerned.

For the clinical physiology of the heart the reader is referred to the writer's article on *Arrhythmia* in the first volume of this Handbook. We must never forget that the heart is essentially a muscle. The ventricular muscle on which the chief burden of maintaining the circulation falls has two predominant functions, contractility and tonicity. When either of these functions falls below par heart failure or cardiac insufficiency results and may be either absolute or relative.

The symptoms and signs of heart failure are numerous. While no single symptom can be depended on alone the two of most practical importance are (1) shortness of breath and (2) unpleasant feelings of pain or constriction referred to the precordium. Where one or both of these symptoms are present during rest one should think of absolute cardiac insufficiency; where they occur on slight exertion of relative insufficiency. The diagnosis is to be confirmed or set aside by an attempt to exclude other possible causes for these symptoms and by giving due weight to any signs of heart disease which may be present. Before proceeding to therapeutic measures one should try to determine whether it is chiefly the contractility or chiefly the tonicity of the heart muscle that is at fault. This is very necessary because of the fact that remedies that do the most good in one case may do positive harm in the other.

Failure of Contractility and Failure of Tonicity.—When from overwork or failing strength the heart becomes unable to cope with the work demanded of it one of two things may happen.

The heart muscle may make supramaximal efforts to empty its chambers and give evidence of the strain it is under by pain or distress. The pain is usually referred to the precordium, arms, or neck and is comparable to the colic of other hollow viscera when trying to overcome great resistance. Along with the subjective symptoms of pain and distress one may sometimes note an irregularity in the force of the contractions causing a more or less typical pulsus alternans. Under these circumstances the heart is said to be suffering from failure of contractility. In cases of this kind the circulation may not show much evidence of insufficiency during rest. There may be little or no venous stasis or edema and the pulse may be moderate in rate and even of good volume. On slight exertion, however, and sometimes even during rest the heart may

> "Strive to do, and agonize to do,
> And fail in doing."

and we may have evidence of its failing strength in pain, shortness of breath, venous engorgement, and sometimes death.

In another group of cases, the heart saves itself for a time at the expense of the rest of the body. As a

result of infection, nerve influence, or unknown cause the muscle fibers relax. The intraventricular pressure which normally acts as a stimulus to more vigorous contractions ceases to have this effect. As the chambers cannot empty themselves easily, they do so only partially and their flaccid walls give way to make room for an increased amount of blood during diastole. Signs of dilatation appear. The muscular rings around the mitral and tricuspid orifices participate in the dilatation and allow regurgitation. This by a safety valve action relieves the pressure in the ventricles. If there has been precordial pain or distress it becomes less severe but the veins become distended, the liver enlarges, digestion becomes impaired, and edema shows itself. As the circulation becomes more sluggish the heart suffers with the other organs and a vicious circle is established giving the condition a progressive character. Such is a fairly typical picture of untreated failure of tonicity.

Taking a suggestion from Sir William Broadbent's classification of aneurysms, we may broadly describe failure of contractility as the heart failure of symptoms and failure of tonicity as the heart failure of signs.

That these two forms of heart failure are essentially distinct is proved by the fact that a man may be in the throes of angina pectoris, an alternating pulse may show that the function of contractility is dangerously depressed, he may even die of heart failure and yet there may be no dilatation of sufficient degree to be recognized. On the other hand, we often find considerable dilatation of the heart in individuals who give evidence of very good contractile function by engaging in strenuous physical work without undue distress.

Failure of Contractility.—Acute failure of contractility is seen in its most typical form in angina pectoris.

Angina pectoris is defined by Sir Douglas Powell as "a sudden paroxysmal disturbance of the heart's function accompanied by severe pain, distressed breathing, and a vague or instant apprehension of death." By excluding other possible causes James Mackenzie has come to the conclusion that attacks of angina depend upon a failure of contractility. This in turn may be due to starvation and degeneration of the heart muscle caused by temporary or permanent narrowing of the coronary arteries, to exhaustion from overwork, or to poisoning by tea, tobacco, or alcohol. Where some of these conditions have reduced the reserve power of the heart an attack may be precipitated by a comparatively slight cause such as a brisk walk, an overdistended stomach, a cold wind, or a vasomotor spasm.

The treatment of failure of contractility is rest. In angina pectoris we give physical rest by putting the patient in the most comfortable position possible, which will usually be that which he selects for himself. A brief rest from excessive vascular pressure may be given by the inhalation of amyl nitrite. Rest from nervous excitement and pain may be promoted by a reassuring manner, the exclusion of talkative and anxious friends, and in severe cases by the administration of morphine and atropine hypodermically. Upward pressure on the heart from distended stomach may be relieved by the withholding of food and the exhibition of carminatives. In some cases there may be a nervous element requiring moral treatment and often bromides and valerian. Drugs of the digitalis class are contraindicated. Where attacks are frequent inhalations of oxygen are serviceable in warding off or relieving them. It is sometimes possible to effect a cure to the extent of preventing recurrences. To attain this end we must regulate the mode of life in accordance with the general condition of the patient and the reserve power of the heart. For medication between the attacks iodide of potassium and arsenic are recommended by many writers. In cases accompanied by valvular disease and dilatation digitalis may be tried cautiously but will often disagree. My most satisfactory results in these cases have been obtained with adrenalin chloride solution or suprarenal tablets given for months and even years.

Cardiac asthma may also be considered under the head of acute failure of contractility. It is a form of dyspnea usually coming on at night and is seen most frequently in cases of cardiorenal disease. The fact about it that is best established is that it is dependent on an intoxication of an acid nature (Lewis). Among the evidences of heart failure seen during an attack are frequent pulse rate (120–140) and more or less pulmonary edema. Though the cases are often very complex and obscure we are justified, I think, in ascribing the circulatory symptoms chiefly to failure of contractility for the following reasons. The coronary arteries are found sclerosed in the majority of these cases as in angina pectoris. Pulsus alternans is sometimes observed. Relief is usually afforded by similar treatment to that found helpful in angina. In cardiac asthma a hypodermic of morphine with atropine usually gives good immediate results and is often the only means at hand to cut short the attack. Better ultimate results may be expected from inhalations of oxygen. As soon as the attack is over attention should be given to the condition of the kidneys and indications will usually be found for curtailing the protein food and for promoting elimination. For the heart, rest always, adrenalin usually, and digitalis sometimes will be found helpful.

Chronic failure of contractility is to be suspected when the precordial pain or distress felt on exertion is out of proportion to the other signs of heart disease. In these cases the pulse may be moderate in rate and of good volume. The heart may show scarcely any signs of enlargement. There may be no valvular murmurs and no signs of congestion of the venous system. In some cases we may find an alternating pulse, which is always strongly suggestive of failure of contractility. In other cases we may have practically nothing to guide us except the distress caused by exertion. Before making a diagnosis we should consider other possible causes of precordial pain such as aneurysm of the first part of the aorta, rheumatism, neuralgia and hyperesthesia of nervous origin. Chronic failure of contractility, like the acute forms, is seen especially in cases of coronary sclerosis with starvation and fatty or fibroid degeneration of the heart muscle. The treatment indicated is first of all rest which should be emotional and mental as well as physical. Of drugs digitalis and its allies are usually disappointing. My personal predilection in these cases is for adrenalin and I have had a number of good results from it in cases of failure of contractility. I have been using this drug in a great variety of cases for about ten years and have formed some conclusions as to its field of usefulness.

Mode of Administration.—The 1–1,000 solution of adrenalin chloride may be given hypodermically in doses starting at eight minims and increased by two minims at each administration until the limit of tolerance is reached. It is my custom to give it every two hours and the limit of tolerance is usually found at between fifteen and twenty minims. There may be some local soreness at the site of injection, but it is not serious enough to interfere with the hypodermic administration being kept up for a few days in a serious case. Where there is time to wait longer for results the solution may be given by the mouth in doses of ten to thirty minims in a wineglassful of water every two hours. Tablets of suprarenal gland desiccated, two grams each, may be given to the number of from six to fifteen daily.

Effects to be Expected.—The hypodermic use of adrenalin is often followed in from three to six minutes by an uncomfortable feeling which may last

two or three minutes. Complaints may be made of difficulty in breathing, a feeling of constriction about the precordium, and violent beating of the heart. These sensations give place in a few minutes to a feeling of relief and easier respiration. I have no fear of a dose which produces the effects described to a moderate degree but look upon them as an indication that the limit of tolerance is being approached and do not further increase the dose. After the administration the pulse may often be observed to become very small for a short time but soon becomes as good or better than before. I have not followed the blood pressure at frequent intervals, but taking it from day to day have never found it unduly raised by suprarenal therapy; on the contrary I have found it fall materially in many cases of inefficient circulation. When given by the mouth suprarenal tablets or adrenalin in full doses often produce similar feelings of violent heart action to those seen after the hypodermic use. An effect that proves the absorption of the drug from the stomach and its tonic effect on muscle is that the dartos muscle of the scrotum often becomes tightly contracted.

Therapeutic Application.—My experience has led me to regard adrenalin as a valuable drug for preventing attacks of angina pectoris and cardiac asthma, for relieving precordial distress in chronic failure of contractility, for increasing the strength of the heart and producing general amelioration in cardiorenal cases, for diminishing shortness of breath in the obese, and for restoring the normal respiratory rhythm in cases of Cheyne-Stokes breathing. In some other conditions, such as hyperthyroidism, I have seen benefit follow its use but the results have been less striking.

I have seen one death follow the hypodermic administration of adrenalin by a few minutes, but the patient was evidently a dying man before it was given. On the other hand, I can remember one patient who was moribund with heart failure to the extent of unconsciousness and uncountable pulse who recovered under its use and lived about a year. I can remember other cases nearly as bad in which the patients seemed to owe their recovery to the use of this drug.

Iodides are often prescribed in these cases, especially where the blood pressure is high. Many writers have borne testimony to the fact that their usefulness is by no means confined to syphilitic cases. Arsenic is another drug which is often prescribed with benefit. In several cases I have seen marked improvement follow the use of a pill containing pil. Blaud gr. x, arsenic, strychnine, and aloin each gr. $\frac{1}{60}$. As improvement takes place a gradual return to activity may be allowed, but the patient should never be allowed to carry exercise to a point where it will cause dyspnea or precordial pain lasting for more than a minute or two. Baths and resistance exercises are much lauded by some and are probably of great benefit in some cases, but their use requires special study at an institute arranged for their administration and also a trained assistant to carry out the treatment.

Failure of Tonicity is more familiar under the name of dilatation of the heart. It is the most typical because the most generally recognized form of heart failure.

The first stage in diagnosis is the recognition of cardiac enlargement by palpation, percussion, or x-rays; the second stage is the exclusion of pure hypertrophy and pericardial effusion by attention to the strength of the cardiac impulse, the character of the heart sounds, and the outline of the precordial dullness. Confirmatory evidence is furnished by diffuseness of the impulse, epigastric pulsation, accentuation of the pulmonary second, embryonic shortening and sharpening of the first sound, valvular murmurs, engorgement of the pulmonary and systemic circulation, edema of dependent parts, and enlargement of the liver and spleen. In treating failure of tonicity the first consideration should be rest, which may be absolute or relative according to the extent of the condition. In moderately severe cases three weeks' absolute rest in bed will be indicated and should be followed by a gradual return to activity. In more severe cases the patient may have to be kept in bed for months. Restful nights should be assured if necessary by the administration of morphine. In acute cases with dilated right heart and engorged veins a venesection will sometimes save life and is not practiced as often as it should be. Drugs of the digitalis group are usually beneficial. When the patient is in imminent danger strophanthin may be given intravenously or intramuscularly in doses of one-fourth to one-half milligram and may be repeated in from three to twelve hours according to the indications. Strophanthone which is marketed in ampoules ready for use is also an excellent preparation. It is well to go carefully with strophanthin till one has some experience with it. When a first dose does good a second dose may do more good or, if given too soon, may be followed by sudden death as occurred once in the practice of the writer.

When the danger is less threatening some form of digitalis may be given by the mouth. The ordinary tincture usually answers very well and may be given in doses of fifteen minims three times daily. Where this dose is ineffectual doses considerably larger may be tried under careful oversight. Some patients show better tolerance for some of the active principles such as one finds in Nativelle's granules of digitalin. Good results have also been reported from the infusion made from the fresh leaves, the powder and various proprietary preparations such as digipuratum, digalen, and Petit Miahl's digitalin. The important matter, however, is to choose the right case for the digitalis rather than the right digitalis for the case. As a rule digitalis should be given in good doses until the pulse slows down to sixty or seventy or symptoms of intolerance show themselves. In the latter case it may be discontinued for a few days and then resumed in smaller doses. If it agrees well the dose may be gradually reduced, but the administration of small daily doses may be kept up for months or years.

Digitalis is a drug to which many patients show marked idiosyncrasies of many different kinds and each case must be studied and treated individually. Patients with auricular fibrillation usually need to take it continuously in small daily doses as long as they live. Those with failure of tonicity with normal rhythm may recover sufficiently to get on without it, or may keep well only as long as they take it. Some indications for stopping digitalis are nausea, diarrhea, dryness of the mouth, aphasia, drowsiness, and partial heart block. So far as known to the writer, no form of valvular lesion is necessarily a contraindication to its use. On the other hand no valvular murmur is an indication for treatment of any kind, except in so far as it may suggest active infection or degeneration or fatigue of the heart muscle. Chronic valvular defects are beyond treatment and can be disregarded in therapeutics except in so far as they throw light on the etiological factors at work.

Sometimes, unfortunately, drugs of the digitalis class are not well borne and have to be given up. These cases furnish the most difficult problems that confront us in connection with heart work. Where the intolerance is limited to the stomach it may be possible to introduce digitalis by enema. Where this also fails it is probable that the heart muscle is considerably degenerated and the prognosis is bad. In a few of these cases suprarenal tablets may do good as in failure of contractility. The period of rest must be prolonged. Theocin may be useful in cases where edema is a prominent factor but in which the kidneys are fairly normal. It may be given in "konseals" in doses of five grains three or four times daily. Hema-

tinies are sometimes our best remedies. Baths and graduated exercises are often recommended.

Having determined what form of heart failure is present and instituted such treatment as may be immediately necessary, we should next endeavor to trace back the disorder to its cause. Until we have dealt with the cause of a disease we have not done our best to prevent its progress or its return.

To determine the cause we need to go fully into the personal and family history of the patient and to examine all the organs which experience has taught us may furnish a clue.

Causes of Heart Failure.—*Congenital heart disease* should be kept in mind as an occasional cause. The general experience seems to be that these cases have to be treated by regulation of the mode of life and general health rather than by heart tonics. We may learn something from the fact that nature usually tries to compensate in these cases by raising the color index of the blood. It is well to estimate the hemoglobin and if it is not distinctly above par we should attempt to increase it by hematinics.

Rheumatism is to be recognized as the cause of heart failure from the personal and family history, the condition of the joints, and the presence of valvular murmurs. In the case of aortic murmurs we must exclude syphilitic infection and sclerotic changes before reaching a conclusion. In all systolic murmurs we must consider the possibility of muscular relaxation from anemia or fatigue. Regard should be had to past attacks of chorea or tonsillitis or febrile attacks of undetermined nature in early life.

When rheumatism is established as a probable cause we must next decide from the symptoms present whether it is still operative. It is of little use to give digitalis to a patient whose heart is being actively attacked by rheumatic or other infection. We must first if possible eliminate the rheumatism and then try to restore strength to the heart. As to treatment I will only say that of the remedies usually given for rheumatism I have personally a great partiality for salicin. It may be given in doses of thirty grains or more every two hours in milk or jam. It is bitter and expensive but is usually well borne and effective. In cases which drag on in a subacute or chronic form I have been well pleased with the results obtained with Schaefer's phylacogen. It may be given hypodermically every day or two in doses starting at from 2 or 3 c.c. and increased to 5 or 10 c.c. if the reaction is not too violent. The treatment should be continued until pain and fever disappear, which will usually be after some 60 c.c. have been given.

Of *malignant endocarditis* I have comparatively little experience but am optimistic enough to believe that we may soon have at our disposal methods of preparing vaccines, by which a fair proportion of these cases may be controlled.

Syphilis may be acknowledged by the patient or some of the stigmata may be found. Aortic disease either of the valves or arch should always raise the question in our minds. The same may be said of heart block. Whenever there is the least suspicion of syphilis a Wassermann test should be made by an expert and if it is found positive the treatment should be carried out with the advice and assistance of a competent syphilologist.

Influenza may be mentioned to draw attention to the fact that it is often accompanied by considerable degeneration of the heart muscle, and a proper rest should be enjoined if one would avoid a certain percentage of sudden deaths during the period of convalescence. This is especially true in the case of patients whose hearts were previously diseased. The same may be said of *diphtheria* and some other infections.

Of *infectious diseases generally* it may be said that the best way to treat the heart is to control the infection itself by specific drugs or vaccines where these are available. Every possible means should be taken to limit physical and mental effort and to ensure sleep. Digitalis is less useful than in the absence of active infection, but I believe I have seen it do good in some cases of pneumonia. In view of the weakened condition of the digestive organs and the need of giving other medication I am in the habit of giving it, if at all, in a single large daily dose. A convenient preparation is a hypodermic tablet of one-tenth of a grain of German digitalin. This may be given by the mouth once daily. Hypodermic injections of adrenalin chloride solution in doses of ten to fifteen minims every two hours have seemed to help some desperately sick patients of mine over the critical period.

Nephritis is often a cause and sometimes an effect of heart disease or both may have a common cause in arteriosclerosis. It may be easy or it may be difficult to determine which is the primary disease.

In favor of primary renal disease are high blood pressure, hypertrophy of the left ventricle, accentuation of the aortic second, history of overeating and alcoholic excess, symptoms of uremia, polyuria with low specific gravity, and granular casts. In favor of primary cardiac disease are valvular murmurs, dilatation of the right heart, accentuation of the pulmonary second, venous engorgement, edema of the legs and scanty urine of high specific gravity.

In either case heart failure if present may be treated as already indicated, with rest and digitalis or adrenalin. In cases of primary nephritis special attention should be given to the diet. Proteins and purins should be strictly limited. A milk diet may be the best for a time.

When edema is a prominent feature it is very necessary to hasten its disappearance by every possible means, as it embarrasses the peripheral circulation. In some cases rest in bed and digitalis are all that is necessary. In other cases some drug acting more directly on the kidneys may be required. If the kidneys are not too badly diseased we have a considerable choice. Mackenzie recommends the old Guy's hospital pill of digitalis, squills, and calomel. Tyson praises sparteine sulphate in doses up to three-fourths of a grain every three hours. Dieulafoy describes Trousseau's wine as "a diuretic which does not exhaust the kidney and a cardiac tonic which does not exhaust the heart." Besides white wine and alcohol it contains juniper berries, acetate of potassium, digitalis, and squills. Care should be taken that the preparation given does not contain more than six grains of digitalis leaves to the ounce as in the original formula. It may be given in doses of one or two tablespoonfuls daily for five or six days. When the kidneys are badly diseased we may have to rely chiefly on drastic purgatives and puncture of the skin. Elimination by the skin should be promoted by woolen underclothing, by hot water or vapor baths, and still better by a sojourn in a warm climate. Of a salt-free diet I have too little experience to speak.

Arterial Hypertension.—A practitioner who treats all cases of hypertension alike is doing about as good work as one who treats all cases of headache with phenacetin, without finding out whether they are due to eyestrain, uremia, or brain tumor. As a frequent result of chronic nephritis, arterial hypertension is an indication for a careful examination of the urine. In some cases the cause will be found in too much work, worry, and whiskey, which may or may not have produced recognizable changes in the arterial walls. All these causes should be sought out and removed. A valuable remedial measure in many cases is judicious exercise. The bowels should be carefully regulated. By improving the brain circulation drugs like digitalis and adrenalin lower the blood pressure in the majority of cases and probably do so permanently more often than any other drugs. In

women high blood pressure is sometimes seen as a result of diminished menstrual flow. The best treatment for these cases is an occasional venesection. I believe, however, that worry is the commonest cause in women.

Obesity throws extra work on a weak heart. The heart usually participates in the poor muscular development which is present. Its movements are interfered with by deposits of fat in and around it. It is often cramped for space by an elevation of the diaphragm, and it has to provide for the muscular work incidental to the movements of a heavy body. Fat people are very prone to anemia and, worst of all, coronary sclerosis is common. In diagnosing the heart condition in obesity great attention should be paid to symptoms as the signs are often indefinite and obscure. The possible existence of a coronary sclerosis should be borne in mind and if there are any symptoms of an anginal character the case should be treated as a failure of contractility. Where there are only such symptoms of relative insufficiency as might be expected from the degree of obesity present some form of reduction cure combined with graduated exercises should be undertaken but should be begun very gradually.

Functional Disorders of the Heart.—So far we have mentioned only the two functions of the heart which are best developed in the mature muscle of the ventricles, namely contractility and tonicity. There are three other functions, which, while probably possessed to some extent by the mature muscle, are more characteristic of the primitive muscle fibers which regulate the rhythm and rate of the heart. These are the functions of stimulus production, excitability, and conductivity.

Changes in these functions do not usually lead directly to heart failure but may do so indirectly by establishing a rate of beat which leads to fatigue, or by bringing about a lack of coordination between the auricles and ventricles.

Disorders of these functions, therefore, must be considered not as forms but as possible causes of heart failure. Some of these disorders lead to different forms of *arrhythmia*. The subject of arrhythmia will be found dealt with at some length in the first volume of this Handbook and it is not necessary to go into any details here. There are a few practical points, however, which must be mentioned even at the risk of repetition.

Auricular fibrillation and paroxysmal tachycardia fatigue the heart by the too frequent rate incidental to these disorders. In heart block on the other hand the ventricular rate is usually too slow to maintain an efficient circulation. Both auricular fibrillation and heart block throw nearly all the work of the heart on the ventricles. Auricular fibrillation is the indication above all others for digitalis whereas heart block is usually a contraindication to its use. From these facts it may be seen how important it is to familiarize oneself with the means of recognizing the various forms of arrhythmia and the proper way of treating them. Allied in some ways to the arrhythmias are the so-called functional disorders of the heart. These are principally affections involving the functions of stimulus production and excitability. These two functions are so related to one another that in our present state of knowledge it is impossible to separate them. It is moreover very difficult to distinguish the disorders of these functions brought about through the cardiac nerves from those which depend on some toxic influence or nutritive change directly affecting the primitive muscle of the heart.

Palpitation occurs in sudden attacks following exertion, excitement, or overeating. It sometimes wakes the patient out of his sleep. Complaints are made of violent throbbing of the heart and neck, sensations of choking, and fear of death. Objectively the action of the heart can be seen and felt to be exaggerated, the neck can be seen to throb, extra systoles may be observed, the pulse is more or less increased in rate, and an arterial tracing will give indication of an empty state of the arteries.

These attacks are most common in females and are usually in part at least of nervous origin. The treatment should to some extent be like that of an attack of hysteria. The manner should be reassuring, friends should be excluded, mental and physical rest should be arranged for. The most useful drugs are stimulants, carminatives, and sedatives. Good results may be expected from ammonia and valerian followed by bromides. Morphine should be avoided if possible but may be required in some cases. To prevent a recurrence the cause must be found and removed.

Paroxysmal tachycardia must always be excluded before a diagnosis of palpitation is made, but for a description of this affection the reader is referred to the article on arrhythmia. Apart from these two disorders we may have a more or less *persistent frequency of the heart's action* without other symptoms, or the heart may respond to slight stimuli with a greater increase of rate than normal. A frequent pulse should be carefully examined as to its regularity, and if any form of arrhythmia is found the treatment appropriate to it should be instituted. In the absence of arrhythmia success in treatment is largely a matter of discovering the cause and removing it. Under functional disorders it is convenient to place the so-called *weak heart*. In its most pronounced form the sufferer may be confined to bed for a long time and any attempt to rise or exert himself may bring on feelings of faintness and extreme feebleness of the pulse. In less marked cases the patient is able to get about but is subject to attacks of syncope from slight causes. The weak heart is usually the result of constitutional weakness or nervous exhaustion and may be partly dependent on a lack of vasomotor tone. It may be briefly described as a chronic condition of shock. The treatment is similar to that for neurasthenia.

Causes of Functional Disorders of the Heart.—*Organic disease* must always be carefully looked for by physical examination and by a consideration of the symptoms before a diagnosis of functional disorder is made.

Sexual influences are among the most common causes, but many men seem to pride themselves on a profound ignorance of these matters and allow the disorders to drag on unrecognized and unrelieved. These influences produce their effects in several different ways.

1. As a result of general and nervous exhaustion incident to excessive venery. This is the principal variety seen in men, but is not common in the experience of the writer.

2. Through the emotions of loneliness or grief as in "maids,' nuns,' and widows' melancholy."

3. By a reflex effect of pelvic congestion due to protracted libido without orgasm.

The last two forms are seen chiefly in women and are extremely common. Some grasp of feminine psychology is very necessary for the understanding of functional disorders of the heart. In a perfectly normal well brought up young woman the sexual life is largely a matter of sentiment. At the most she can say with Browning's Pauline that

> "She has strange powers and feelings and desires,
> Which she cannot account for nor explain,
> How can her life indulge them? yet they live,
> Referring to some state of life unknown."

At this stage of development the sexual causes of disease are chiefly of the emotional type, and will be more conveniently considered under the head of emotional disorders and those due to hyperthyroidism.

At the other extreme are women in whom as a result of degeneracy, indolence, or evil communications

the desire for sexual gratification has become an obsession. To adapt once more the words of Browning they are

> "Hungry for joy; and, bravely tyrannous,
> Grow in demand, still craving more and more,
> And make each joy conceded prove a pledge
> Of other joy to follow — bating nought
> Of their desires, still seizing fresh pretence
> To turn the knowledge and the rapture wrung
> As an extreme, last boon, from destiny,
> Into occasion for new covetings,
> New strifes, new triumphs."

Many women approximating to this type suffer even during maidenhood from severe attacks of palpitation and cardiac distress. These are sometimes brought on by prolonged caressing and sometimes by self stimulation which, be it noted, may be either physical or psychical. For such cases one can hardly improve on the general principles of treatment laid down in Burton's Anatomy of Melancholy. Sparing diet, phlebotomy, and physic "but the best and surest remedy of all is to see them well placed, and married to good husbands in good time." Except in the worst cases of moral insanity one may count a good deal on the vis medicatrix naturæ, which operates in the mental and moral as well as in the physical constitution. Ignorance and thoughtlessness are often at the bottom of the trouble and much can be done by kindly words of counsel. This may well be followed up by a course of bromides and better still by some healthy occupation for mind and body.

Indiscriminate instruction of young people in sexual matters has much to answer for. It is open to the objection of supplying new and often unnecessary facts for the imagination to work upon. Such limited instruction as is necessary for a healthy young woman is best given by a wise mother. The abnormal and diseased may require instruction and advice from a physician. Among married women the chief sexual cause of functional disorders of the heart is coitus interruptus, the prevalence of which it would be impossible to exaggerate. The diagnosis of a typical case is easy. A woman complains of nervousness and uneasy fluttering about the heart, often of severe attacks of palpitation. She has been living with her husband for some time without becoming pregnant. She has leucorrhea and suffers from malaise for from three days to a fortnight before each monthly period. On examination the uterus and ovaries are found to be tender and perhaps swollen. There is a clear viscid discharge from the cervix. In such a case one is justified in putting a direct question and the answer will rarely be other than yes.

The treatment of these cases is often difficult because we cannot come to an agreement with the patient on questions of ethics. If she will discontinue the injurious practice and accept the risks of maternity we can safely assure her of rapid recovery from her heart symptoms. If from selfishness, poverty, lack of maternal instinct, or dislike for her husband she absolutely refuses to accept the responsibility of motherhood the physician is on the horns of a dilemma. He must either allow his patient to go on suffering and probably see her becoming progressively worse, or else he must do violence to his own convictions by suggesting some mechanical or chemical means by which she can attain her end. In any case the symptoms can often be relieved and recovery hastened by glycerin tampons, a course of Turkish baths, or a change of air and scene.

Other causes of heart disorder in married women are relative frigidity and prolonged continence. The symptoms are similar to those just described but are usually milder in type. To treat these cases successfully a medical man requires both knowledge and wisdom which can be acquired only by experience and meditation. He will sometimes have to deal with a cruel or unsympathetic husband.

Emotions and Hyperthyroidism.—The principal emotions leading to disorders of the heart are fear and grief. The disorder may take the form of increase in rate or dilatation or both. In many cases we find enlargement of the thyroid gland and all grades are seen up to typical Graves' disease. No examination of the heart can be considered complete without a careful examination of the thyroid gland. We often have a vicious circle in which the emotions, the thyroid gland, the heart, and the sexual system participate. In these cases psychoanalysis is very important and the best therapeutic agent may be the personality of the physician. Mental and physical rest should be arranged for according to the individual needs. No drug so far as known to the writer is of universal applicability but an attempt must be made to break the vicious circle somewhere. Atropine, ammonium bromide, quinine hydrobromide, emmenagogues, digitalis, suprarenal and other organic preparations all have a place. In chronic cases where hyperthyroidism is a marked feature partial removal of the thyroid gland is often followed by brilliant results.

Physical overexertion produces several varieties of heart disorder. Dr. Tait Mackenzie has recently pointed out that various murmurs may be noticed in a considerable proportion of healthy young men after a short run. They are most distinct in the recumbent posture. No treatment is required as they disappear spontaneously. A word of caution may be given against indulging in violent exertion when out of training. In another group of cases after a season of bicycling, hockey, or rowing one finds dilatation of the heart which may persist for some time and may or may not be accompanied by murmurs. In these cases absolute or relative rest should be insisted on till the signs disappear. Very often a heart tonic like digitalis will materially hasten convalescence. One will often find contributory causes at work, such as tobacco, and these may have to be given up before the patient can enter into strenuous games. In others the constitutional vigor is sufficient only for moderate physical work.

In a third class of cases to which the name *irritable heart* has been exclusively given by Da Costa and others the condition is much more serious. Among the complaints are frequent heart action on slight exertion, pains, palpitations, and irregularities. These symptoms are often accompanied by considerable enlargement of the heart. The condition is usually chronic and incurable. Other causes besides physical strain have been at work such as syphilis, alcohol, and tobacco. There may also be an hereditary tendency to cardiovascular disease. In these cases we have really to do with a myocarditis or a cardiorenal sclerosis and they are mentioned under functional disorders only as a matter of convenience. The treatment is to be carried out on the lines indicated in speaking of the cardinal types of heart failure.

Toxic.—The most common cardiac poisons are alcohol, tobacco, tea, and coffee.

Alcohol, besides leading to degeneration of the cardiovascular system, may be responsible for various degrees of acceleration of the heart rate with feelings of weakness and distress. The acceleration may be fairly constant for days or weeks or may show itself only on exertion or excitement. The diagnosis of alcoholic poisoning is to be made from the appearance of the patient, the presence of other suggestive symptoms, and the history. The fact that some of the symptoms complained of may be of a gouty nature should be remembered. The treatment is the enforcement of total abstinence, with moral support, rest in bed, and such general measures as may seem necessary. Bromides will usually be indicated. Where improvement is long delayed one should assure himself that his orders as to abstinence are being obeyed. Sometimes the conclusion will be forced

upon us that more serious organic change has occurred in the heart or kidneys than was at first suspected. In such cases a longer rest will be indicated and digitalis or adrenalin may be required to get the heart into a condition where active life can be resumed.

Tobacco poisoning may manifest itself in the following ways:

1. Attacks of faintness with frequent heart beat, sweating, and nausea, chiefly seen in novices.

2. Attacks of palpitation with frequent extra systoles sometimes seen in cigarette smokers who inhale.

3. A form of excitable heart with frequent pulse, diffuse apex beat, and incapacity for exertion.

4. Attacks of angina pectoris indistinguishable from those due to organic disease. In these cases one should always consider the possibility of there being some coronary sclerosis present.

In reaching a diagnosis of tobacco-heart some weight may be given to the presence of gasping or sighing respiration which is very suggestive of tobacco poisoning as pointed out by the writer some years ago. In treatment the one great essential is to persuade the patient to give up tobacco. It is usually easier for him to give it up altogether than to reduce the quantity. Where the writer has allowed smoking to be continued, even to a slight extent, he has nearly always had relapses to contend with. When an attack takes the form of angina pectoris it should be treated as such.

Tea and *coffee* sometimes produce symptoms very like some forms of tobacco poisoning. In the writer's experience serious disturbances of the heart from these beverages are rare, but the possibility should always be considered in dealing with functional disorders of the heart or attacks of angina pectoris.

Digestive disorders may affect the heart mechanically by upward pressure of viscera distended by gas, reflexly through the cardiac nerves, or chemically by absorption of the products of fermentation. All these factors are operative in cases of fermentative dyspepsia. In the experience of the writer the most frequent sufferers are people with defective back teeth. The teeth like the thyroid gland should be carefully examined in all patients complaining of palpitation, or extrasystoles, or showing signs of cardiac dilatation. The best treatment in cases with defective teeth is proper attention by a good dentist. For temporary relief I known of nothing better than a good malt preparation of which Keppler's extract is one of the most reliable.

Some heart disorders can be traced to the new breakfast foods which contain half cooked starch and often cellulose. I have seen patients recover rapidly from grave heart symptoms by simply discontinuing the use of these cereals. The most suitable diet for those suffering from either organic or functional heart disease is easily digestible solids. Soups, broths, porridge, and bulky foods generally are to be avoided.

Neurasthenia should always be thought of in functional disorders of the heart, whether of the excitable or weak type. An account of this disease will be found in another part of this HANDBOOK. I would like, however, to mention the fact that where splanchnoptosis is present some improvement in the heart symptoms may follow the use of a good abdominal supporter.

In *conclusion* I would remind the reader that the elements into which we have tried to analyze the manifestations and causes of heart failure are usually found in combination. It is for us to separate them and place them in proper perspective. In obscure and difficult cases we can scarcely go wrong in prescribing rest in bed. My parting advice is to remember the boast of Karl Wenkebach, that if ever he should acquire a reputation for treating heart patients, it would be from giving digitalis in cases where authorities and text-books forbid it.

WILLIAM S. MORROW.

Heart: Myocardial Diseases.—Our knowledge of myocardial diseases began when Laennec discovered that cardiac muscle underwent fatty degeneration. A quarter of a century later, fatty deposition was contradistinguished from fatty degeneration, Stokes tracing it to infective diseases, particularly typhus and typhoid fevers, and Hayem confirming Stokes' findings by microscopic examinations. In 1856, Ricord reported that syphilis attacked heart muscle; and during our Civil War Da Costa called attention to the "irritable heart" he had detected in soldiers after severe prolonged marches. Later, Bristowe found that there was also interstitial disease of the heart tissue. It occurs in diphtheria and scarlet fever, and Huchard traced its origin in some instances to inflammation of the coronary vessels. Finally, in 1878-9, von Leyden of Berlin showed that there were successive stages in the development of the fat heart, and gave clinical pictures of each one.

As a result of these investigations, we may now say that all toxemias, acute or chronic, some dyscrasias and intoxications, if long continued or severe, and other affections to be mentioned later produce definite changes in the heart walls, evanescent or permanent, as the case may be. And although we cannot always connect definite clinical phenomena with each pathological change, still in most cases we may picture in our minds the particular myocardial change and its stage.

The word myocardium, referring as it does to muscle tissue as the preponderating element in the heart walls, is to be here understood as a synonym for the heart walls themselves (Fig. 3092). But with regard

FIG. 3092.—Normal Heart Muscle. × 250.

to the word *myocarditis* there has been much misapprehension. Some still use it, either indiscriminately or as the equivalent of myocardial disease in general, though properly it means myocardial inflammation, and therefore does not include the most common of all myocardial affections, degenerative changes.

Classification.—My classification of myocardial diseases includes:

1. Acute parenchymatous myocarditis.

2. Acute diffuse myocarditis, including the tuberculous, syphilitic, rheumatic and suppurative forms.

3. Chronic myocarditis, including all of the diffuse inflammatory changes mentioned.

4. The fat heart.

5. The fatty heart.

6. Hypertrophies, whether due to severe exercise, vascular diseases, blood disorders, neurotic disurbances, possibly pregnancy.

7. Atrophies.

8. Hyaline and calcific changes.*

Some such classification as the above is essential for a clear conception of myocardial diseases, though many of the pathological phenomena here given are apt to be interconnected in any one instance. In fact, this complicated interrelation has led some internists to emphasize the clinical aspects of these affections at the expense of the pathological. Of course, it is true, in a general way, so far as symptoms and treatment are concerned at least, that chronic myocardial insufficiency is sometimes synonymous with myocardial abnormality or disease; but it is not so always. For example, the insufficiencies of the syphilitic heart and fat heart differ widely from others of the

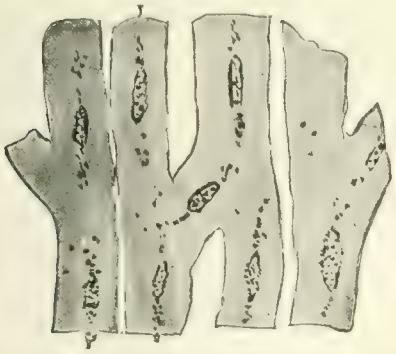

Fig. 3093. Acute Parenchymatous Change. × 250.

myocardial group, so that they need to be classed separately, while the more we study these subjects the greater will be the variations discovered.

Frequency.—By those who are familiar with ordinary pathological views as to the origin of acute affections in general, it will be admitted that parenchymatous changes in the cell elements of a part are such regular precursors of inflammatory conditions that they are to be considered as early symptoms. And so a parenchymatous myocarditis may be but the first indication of the diffuse form, even though the character of the parenchymatous change is not fully understood. However, it is to be presumed, from what we know of similar processes elsewhere, that parenchymatous changes may not only produce fatty degeneration of the muscle cells, hyaline change, and calcification, but necrosis as well, leading to dilatation and perhaps even to rupture of the organ.

We have only recently begun to appreciate the comparative frequency of myocardial disease. According to Harlow Brooks,[2] of 457 cases taken from his list of autopsies where death was credited to cardiac diseases, in 330 the heart walls were sufficiently diseased to cause death, while in many of the others myocardial disease was a contributing cause. Unfortunately, in a considerable number the disease had not been recognized during life, though in 126, or thirty-eight per cent., the myocardial disease was uncomplicated.

Some years ago, in looking over my own clinical records, taken from both hospital and private memoranda, I came to the conclusion that probably in forty-five per cent. of my deaths in cardiac cases degenerative changes in the myocardium were the chief determining causes. Roemer, during a period of twenty years, had a record of forty-four per cent. of myopathic heart failures where there were no valvular symptoms, so that our clinical figures tally closely. Romberg has found chronic cardiac insufficiency (by which he means chronic myocardial disease) the most common of heart affections, at least between the ages of forty and sixty-five in men, and in women at a little later period. If to these chronic forms we add all the acute myocardial affections associated with infections, dyscrasias, anemias, intoxications, etc., we may be tolerably sure that myocardial disease is more frequent than valvular disease. But cardiac disease other than valvular or myocardial is very rare, while valvular disease is tolerably sure to produce more or less myocardial disease. So that it is easy to see that the latter is certainly the most common form of heart disease, and probably more so than all other forms combined. Schott[3] says that diseases of the myocardium, in comparison with those of the endocardium, are as five to two.

Pathology.—With respect to the morbid changes of the tissues, parenchymatous alteration is the earliest of all. In diphtheria, for example, it may occur within the first few days, or at any time up to several weeks after the fever has subsided. Acute parenchymatous change is characterized, pathologically, by the occurrence of minute granules or particles in the muscle cells, and the partial disappearance of the cross-striations. This early parenchymatous change is probably analogous to the "cloudy swelling" seen in the uriniferous tubules at the onset of an acute nephritis (Fig. 3093). It antedates, I think, every other sign. Though diphtheria appears to be largely responsible for myocardial disease (Schmalz found it in sixteen per cent. of his diphtheria deaths); it also occurs in rheumatism, with or without the articular signs, in tuberculosis, tonsillitis, measles, lobar pneumonia, erysipelas, epidemic influenza, septic processes, gonorrhea, and probably in all severe infections and intoxications. The parenchymatous change may be localized or general, usually the latter. Seen with the naked eye the muscle tissue is lighter colored than normal, while the cut surface is lack-luster in appearance, swollen, and moist. Microscopically the muscle cells are enlarged, less translucent than usual, and studded with minute particles, bacterial in character, or derived from the albuminoid protoplasm of the cells. In advanced cases the nuclei are similarly transformed. In 1904 Aschoff found peculiar minute nodules in the myocardium, associated with acute articular rheumatism. He thought they were specifically related to the rheumatism. Frankel thinks they are formed in the periadventitial tissues of the smaller vessels. It is probable that myocardial changes may be either due to the toxins of the infections above mentioned or induced by

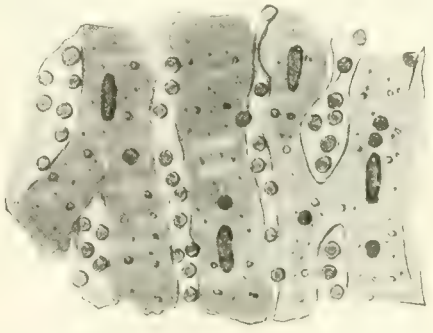

Fig. 3094.—Acute Myocarditis. × 315.

continued fever or by dyscrasias such as alcoholism. The mechanical effect of these changes is to limit the contractile power of the muscle and cause cardiac inefficiency sooner or later. When acute myocarditis has become established it is seen that the muscle bundles are not only swollen with serum, filled with granules, and opaque, but the muscle striations may be nearly obliterated. Segmentation and fragmentation (Fig. 3095) are said to occur occasionally. We need not treat these last-named conditions too seriously; they may be antemortem or postmortem

*Pappenheim[1] has described at length this rare condition

phenomena. In all cases, however, the intermuscular tissue is also infiltrated with blood globules, together with the proliferating cells of the interstitial tissues and vascular sheaths.

What we call *acute myocarditis* is therefore a (Fig. 3094) diffuse inflammation in which the muscular tissue is only one of several elements involved. It may be localized or not. Occasionally the process may go on to suppuration. Usually the abscess

Fig. 3095.—Segmentation and Fragmentation. × 110.

is embolic and multiple, sometimes due to infective endocarditis, to pyemia, or to some other infection. It is usually fatal, discharging into one of the cavities of the heart, or into the pericardium, causing aneurysm, pyocardium, pyopericardium, or even rupture of the organ. But the acute form may pass over into the chronic. For example, acute tuberculosis of the heart walls may become chronic, and the same is true of syphilis, gout, and some other affections. In fact, there is no doubt that in all these instances the disease which at first originated in the larger cardiac vessels or their perivascular sheaths extends to the interstitial tissues along the lines of the smaller vessels. Even the elastic tissue may be involved, and this is a very important factor in the heart action, its expansion and contraction being an aid to the muscular mechanism.

Cardiac hypertrophy is due, apart from severe exercise, to such causes as arteriosclerosis, congenitally small vessels, scoliosis, kyphosis, Graves' disease, and the neurotic heart of hysteria. In sclerosis of the coronary vessels, the process starts from the vessels or their sheaths, and then extends along their subdivisions throughout the heart substance, increasing its thickness and density. If the congenitally small vessels described by Virchow are present, the muscular tissue of the heart may hypertrophy in order to propel the proper amount of blood through the narrowed arterial channels. In scoliosis and kyphosis, the heart walls hypertrophy because the movement of blood through the heart chambers is restricted by the constriction of the bony framework of the thorax, and some pressure must be brought to bear on the right or left ventricle, as it may be, in order to maintain the circulatory equilibrium. In Graves' disease and in the hysterical heart the increased activity of the organ, due to the neurotic condition, increases the heart's rapidity, and, if continued, eventually causes muscular hypertrophy.

The fat heart and fatty heart are closely allied, pathologically speaking, but in uncomplicated cases there is little in common between them as to natural history, diagnosis, and prognosis. In the fat heart there is a deposition of fat between the muscle fibers or bundles (Fig. 3096), while in the fatty heart there occurs a degeneration of the muscle fibers themselves (Fig. 3097).

In the *fat heart* there will not, in ordinary cases, be any interference with the function of the muscle; in advanced cases the fat may of itself interfere with the motility of the fibers by external pressure. In fatty degeneration the protoplasm of the muscle itself has undergone a change that necessarily restricts its energy, and may eventually destroy its vitality in whole or in part. The fat heart tends to degeneration; that is it is apt to evoke degenerative changes in the muscle against which it presses; but a fatty heart never becomes a fat heart.

The fat heart and corpulence are so closely allied that Quain once maintained that patients with fat hearts were invariably corpulent. Patients with fat hearts are generally corpulent, but not always; but there is certainly a pretty constant relation between the two. Yet if a corpulent person is reduced by treatment, the fat about the heart is apt to remain long after the external evidences of fat deposition have yielded. On the other hand, beer drinkers and gluttons put on bodily fat which their hearts often do not share. With these exceptions, corpulence and the fat heart may be said to be practically coincident. The fat heart may occur at any age, but is rare in advanced life. As the atrophic changes of senility set in, the deposits of fat usually disappear. Von Leyden has described three varieties of the fat heart: (1) Where there is a deposit of fat in the heart walls without organic affection of the muscle tissues. (2) A severe form associated with organic muscle disease. (3) A form complicated with disease of the aorta and coronary vessels, perhaps of the kidneys. There can be little doubt as to the occurrence of the first two varieties.

Fatty degeneration is more common than the fat heart. At the present, evidence seems to favor the idea that the oily particles come from without, though

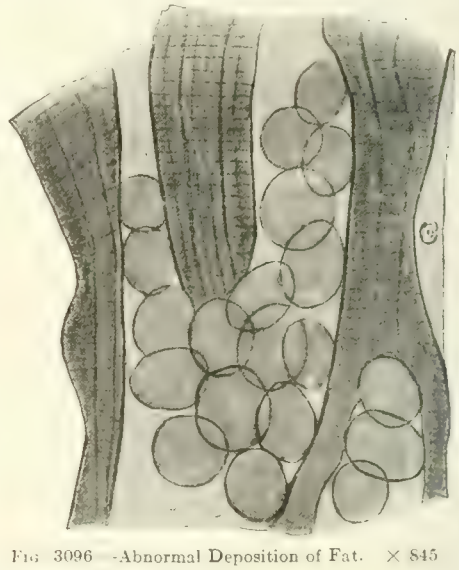

Fig. 3096.—Abnormal Deposition of Fat. × 845.

it is more natural to believe that they come from within the muscle cells and are sequels to the albuminoid changes of acute myocarditis, especially as they are found in the very class of cases that suffer from acute myocarditis, as in the eruptive fevers, diphtheria, acute rheumatism, lobar pneumonia, influenza, tonsillitis, cellulitis, enteritis, or any acute attack of

toxemia; also in chronic intoxications, such as lead poisoning or uremia. But fatty degeneration (Figs. 3097 and 3098) is also found in wasting diseases like carcinoma and paralysis, in prolonged fevers, after mechanical injuries or surgical operations, in severe depression of the system, in pregnancy, and in senility. When, in the affections named—especially in the toxemias due to diphtheria, in eruptive diseases, cellulitis, suppuration after operations—sudden death occurs, the probability is that the mischief is due to fatty degeneration of the organ, and the cause a toxemia rather than an embolism, heart clot, or cardiac paralysis, which in times past were terms used to explain these accidents. In fact, we may go so far as to say that diseases of the heart substance in which fatty degeneration plays an important part are the chief causes of death in heart disease. Predisposing if not governing factors of fatty degeneration, however, are cardiac hypertrophy, fibroid disease, the fat heart, endo- and pericardial diseases, including tuberculosis, new growths, and arterial disease, overexertion, overexcitement, abuse of eating or drinking, very likely anemia. It is unfortunate that coronary sclerosis has been regarded by some as the main predisposing factor in fatty degeneration. Evidence does not sustain this view. Coronary sclerosis is one of the rarer causes of fatty degeneration. In seventeen cases of myocardial disease recorded by Anders,[4] arteriosclerosis was only present in eight, and then not in a prominent degree. While fatty degeneration may occur at any age, the grosser forms are certainly associated with other degenerative changes that are the concomitants of senility. It is certainly more common in advanced age than middle life. So that being both the most dangerous form of heart disease and comparatively frequent, the importance of an early and correct diagnosis is apparent. Unfortunately, however, its diagnostic features are not strongly marked, and in mild cases may be absent; in fact, there may not be any appreciable dilatation, and this is the one sign of paramount importance.

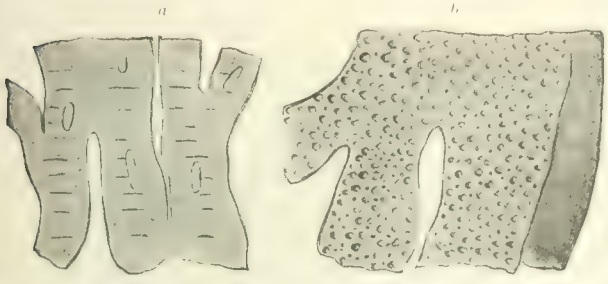

FIG. 3097.—Fatty Degeneration of Cardiac Muscle. *a*, Beginning changes; *b*, complete degeneration. × 250.

Cardiac syphilis has been known to exist for more than fifty years, but my experience has told me that the danger of constitutional syphilis has not been duly appreciated. One reason has been the difficulty of determining the existence of syphilis at autopsies, for, with the exception of the gumma and some peculiar changes in the liver, lungs, and spleen, there have been no certain criteria until the discovery of the *Treponema pallidum*. It will not be long, however, before we know the relative frequency of cardiac syphilis, for according to Warthin the treponema is found more frequently in the heart than in the lungs, liver, or spleen. Another reason why the danger of heart involvement in syphilis has not been appreciated is that such involvement usually occurs very late after the initial lesion, even eight or ten years afterward, when the patient has begun to forget that he ever had the disease, or has thought it cured. It should also be remembered that cardiac syphilis may be hereditary. Some years ago I found from my clinical records that syphilis positively existed in five per cent. of my heart cases, and probably in five per cent. more. I hold to this position still. Certainly there is a class of heart cases with a previous syphilitic history, or perhaps with locomotor ataxia, or some other affection of the central nervous system, where treatment will be ineffectual without the use of mercury or the iodides. It is well known that there is a comparatively close relation between syphilis and aortic disease, and a still closer one between syphilis and aneurysm.

Atrophy of the heart occurs, but is comparatively rare. It may be a family peculiarity, or due to arrest of development, starvation, or some wasting disease such as cancer or phthisis, or simply old age, when it is to be regarded as physiological. The adult atrophic heart has been known to weigh only about three ounces, in fact a little less. These hearts in uncomplicated cases have a dark reddish-brown color, and are in the condition that has been called "brown atrophy." The muscle fibers have yellow-brown pigment about the nuclei. Sometimes the organ is so shrunken that its vessels are thrown out into relief, the "withered apple heart" (Fig. 3100). But there are no very distinctive physical signs of it during life. Of course, in uncomplicated instances the heart's area will be smaller than usual. Otherwise, the signs that have been described, such as faint turns, singing in the ears, palpitation, precordial distress, irregular pulse, and confusion of mind, will be suggestive, in conjunction with the diminished area, but they cannot be called pathognomonic. However, the diagnosis may be made with reasonable certainty, if the heart is anatomically small, either in old age or in any of the affections mentioned above, especially if the pulse is weak and irregular, and there are fainting turns with cardiac distress. Such a heart came under my observation at a meeting of the New York Pathological Society, some years ago. It was taken from the person of a young man who died of sarcoma in the practice of Dr. R. E. Van Gieson. The heart weighed less than five ounces. In Bramwell's female cancer patient, the heart weighed only two ounces,

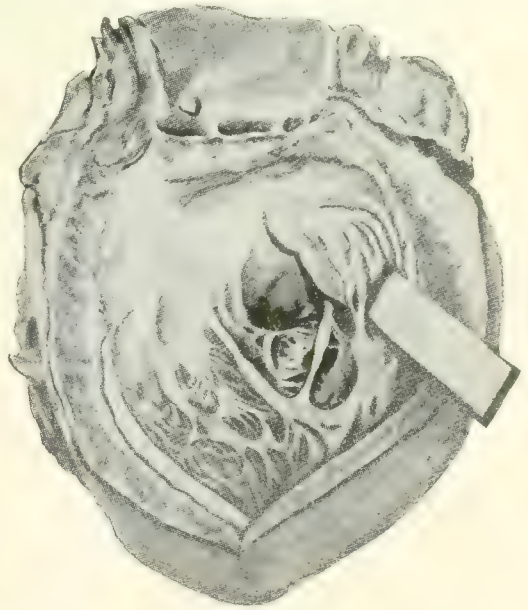

FIG. 3098.—Fatty Degeneration of Heart, with thickened aortic leaflets and mitral stenosis (wooden wedge in button-hole opening); about one-half size.

twelve drams, and ten grains. Fig. 3100 is a life-size copy of Bramwell's case. According to Gibson, Quain knew of a still more remarkable instance in a girl of fourteen, whose heart weighed only one ounce, fourteen drams.

Fig. 3101 is the heart of a female patient of mine who died at St. Luke's Hospital of purpura hemorrhagica. Subserous hemorrhages had occurred beneath the nedocardium. There were similar effusions beneath the submucous tissues of the intestine and uterus. At the postmortem there was found a cardiac collosity, or invading fibrosis, which, as no other explanation offered, may perhaps have resulted from a previous pericarditis.

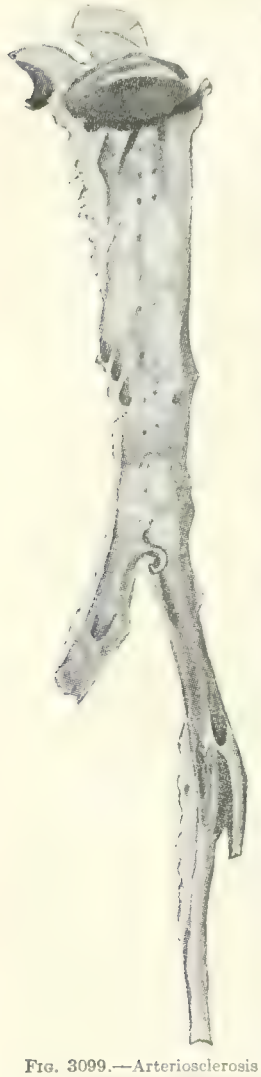

Fig. 3099.—Arteriosclerosis of the Abdominal Aorta, reduced to about one-third size.

In Fig. 3102 we see how an invading fibrosis can squeeze the muscular tissue.

Another method by which cardiac fibrosis develops is shown in Fig. 3103. Supposing that in aortic endocarditis, as in Fig. 3098, a particle is dislodged and finally arrested in a coronary artery, an infarct (white) may result. For the coronary vessels, though not terminal as in the brain, have sometimes rather insignificant capillary connections, and the plugging of an arterial branch may cut off from the neighboring territory so much blood that it is practically starved to death. As a consequence, the muscle tissue involved, with such vessels as exist, atrophy, and the whole area is supplanted by fibrous material. The cardiac walls are then correspondingly weakened, and lose a portion of the tissue which regulates the contraction and expansion of the organ.

Herrick[5] has recently urged that the coronaries are not strictly end arteries, as once claimed by Cohnheim, but that there is an anatomical anastomosis, and that sudden death is not a necessary consequence when even a large branch of a coronary has been obstructed. In fact, while sudden death may be so caused, he holds that it may be postponed for several days, and recovery may take place. He has cited a case where his patient, a man of fifty and of previous good health, was suddenly seized with epigastric pain, high up. In about three hours the pain subsided, but the patient only survived fifty or sixty hours. An autopsy showed obstruction of the left coronary. The most striking symptoms were the initial pain, collapse, feeble pulse and heart sounds, slight dyspnea, and cyanosis. The late N. M. Heineman, as early as 1900, claimed that in the capillary circulation of the heart there were peculiar reservoirs for the blood, unlike anything else of the kind in the body. E. Libman, of the Mount Sinai Hospital, has found partial or complete occlusion of coronaries, particularly in heavy smokers of cigars Sometimes the occlusion was caused by plaques due to arteriosclerosis, or to puckering. Such patients sometimes live not only weeks but months. The facial appearance has been found to be helpful at times in the diagnosis; the skin has a peculiar dirty ashen hue. It is important to recognize this peculiar cast of countenance, as such patients are apt to succumb at any time, particularly after operative procedures (R. H. Fitz).

Cardiac hypertrophy consists in a gradual thickening of the heart's tissues, with dilatation and enlargement of the muscle cells; perhaps an increase in their number. During this period, which may be called the first stage, the pulse is irregular, but its strength increases, the accentuation of the second

Fig. 3100.—Bramwell's "Withered Apple" Heart; natural size.

pulmonary sound at the base indicating that the right ventricle has become enlarged. This stage is completed when the hypertrophy has been sufficient to propel the blood column with the required amount of force. The second stage is marked by a return of the action of the heart and pulse to their normal conditions. This stage may continue indefinitely, so far as we know. If, however, the dilatation increases, as it may from various causes, we then enter upon a period of failing compensation. This is the third stage. But now a sudden further dilatation will mean heart failure, and, if no relief is given, immediate death. Loss of rest, excitement, insufficient nourishment, unusual exposure, sudden strain, may, any one of them, cause sudden dilatation of the heart and death. And yet we should remember that cardiac hypertrophy itself is in all instances a benign process, devised by nature to relieve a worse condition.

For in all these cases, even in the hypertrophied heart of an athlete, the muscular tissue has doubtless been reinforced in order to restore the tone of the organ, in recompense for a strain, or, in other words, a laceration. The diagnosis should present little difficulty. Except in very stout persons, or women with pendulous breasts, the outline of the heart can usually be made out with sufficient accuracy. Even if it cannot be well defined, the apex beat can be located by the stethoscope.

Fig. 3101.—Callosity at Apex of Heart in a Case of Purpura Hemorrhagica; about one-half actual size.

Cardiac hypertrophy therefore indicates the existence of some systemic primary defect or disease, which governs the prognosis, unless there happens to be an intercurrent incident or accident to provoke heart failure. Cardiac hypertrophy in nephritis should not, of course, be taken too seriously; the nephritis is the chief danger. But the athlete's heart is more liable to suffer from excitement or sudden strain than the normal heart, so that he should be warned, in order that he may guard himself against sudden dilatation. In mild cases, however, the hypertrophy may entirely disappear. In growing boys the recovery takes place within a couple of years.

Heart Strain.—In forty unselected school boys, ranging in years from seven to fourteen, taken out for a week's excursion by Riviere, twenty out of thirty-three were subsequently found to have acquired serious heart enlargement. In ten of these there was cardiac shrinkage in from two to ten weeks, while in the remaining ten the enlargement had persisted at the end of two and a half months. In the boys seven and eight years of age, an enlargement occurred in eighty-three per cent.; in the boys of ten and twelve in seventy-five per cent.; in the boys of thirteen and fourteen, only 3.6 per cent. The claim of Duke[6] that modern athleticism is injurious to the undeveloped youth, rests therefore on a sound basis. And it is supported by the evidence of Savage, who with his associates has studied the effect of Marathon races on the heart, and has reached the conclusion that between the ages of twenty and forty athletes are best able to endure the unusual strain. Exercises that bear heavily on the legs, according to W. B. Anderson, give rise most frequently to heart strains, and he classifies these as the acute and chronic, putting Da Costa's irritable heart in the latter category. Schott's experience with athletes[7] is to the effect that exercises carried to the point of producing palpitation and severe dyspnea will cause cardiac enlargement that may become chronic. And yet John Morgan[8] has found that men who have taken part in boat races in early life have as a rule had long and active lives. On the other hand, R. Tait McKenzie[9] claims (and his views are not necessarily in disagreement with those of Morgan) that men who have been very strenuous in athletics in early life cannot safely continue them at a later period. In these persons, also (apart from the possibly fatty condition of their myocardia), the strain on the heart muscle must often be severe, because there is usually a disproportion between the size of the heart and the tissues to be supplied with blood. For there is no fixed relation between the size of the heart and increase in the fatty tissues. More dangerous than athletics, McKenzie holds, are strenous occupations like coal and iron mining, with their unsanitary conditions. Among accessory causes of heart strain must be included malformations of the bony wall of the chest, as in scoliosis or kyphosis, or alterations in the shape of its interior as a result of pursuing certain occupations. For example, the clerk writing at his desk, or the dentist at his chair, take positions which diminish the capacity of the chest and so embarrass the circulation within it, and consequently give the heart greater work to do.

It has been my experience that adults as well as those in early life may suffer for years from severe strain of the heart, and yet ultimately recover from it. A male patient of mine, thirty-two years of age, has quite recovered from a severe cardiac strain which happened six years ago. The outlook is much less favorable, however, in older cases. Another patient of mine, while on a hunting trip in middle life suddenly realized that he had strained his heart in attempting to roll over a heavy log to build his camp. He was a physician, and was fully alive to the fact that his heart had been permanently disabled. Subsequently, under a sudden dilatation from a cause incidental to the life of any busy practitioner, he was taken off without warning. The fatal issue in his case could hardly have been avoided, so long as he discharged the duties of his very responsible and arduous position.

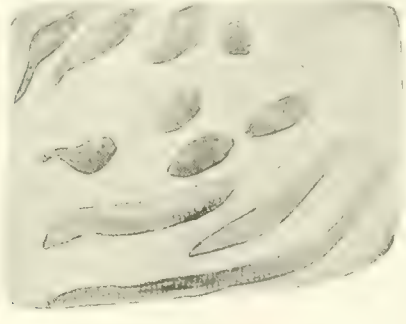

Fig. 3102.—Fibroid Invasion of the Myocardium. × 210

In any case of suspected dilatation, it is extremely important to determine how much hypertrophy is present, certainly to the extent of noting the altered location of the apex beat or sound. Dilatation is characterized by a soft, weak, and irregular pulse, which is usually increased in rate unless the nervous system is implicated or there is renal toxemia. The dilatation may be more or less extensive. But, clinically speaking, if the left margin of the heart does not extend beyond the nipple it is not an alarming sign; if it is much beyond that point the prognosis is unfavorable. In mild cases, however, the dilatation, as shown by the apex beat, does not reach to the

nipple. If, then, in the course of or after typhoid fever, diphtheria, or any of the acute or chronic toxemias that have been mentioned, the pulse becomes weak and irregular, no matter what its rate, attention should be directed to the probability of some myocardial affection being present, and if there is precordial distress, or cyanosis, dyspnea, some edema, or, in extreme cases, anginoid attacks, a diagnosis of acute dilatation can be made with a reasonable degree of probability, which will amount to a certainty if it is found that the heart's dimensions have suddenly enlarged. In such cases we should give the heart as much relief as is practicable by rest in bed; for the horizontal position relieves the weakened organ, the diminished number of cardiac contractions accomplishing the same as a greater number when the body is vertical. If the parenchymatous change is associated with apyrexia, sponging of the surface with alcohol and water will reduce the temperature, while there may be also a field for an antipyretic drug, such as aconite in small doses. In apyretic cases, as in the various forms of chronic cardiac disease, it is more logical to relieve the peripheral pressure by warmth to the extremities, or by the use of nitrites or nitrates, than to stimulate the heart. For whatever temporary gain may be obtained for a tired heart by a cardiac compressor, cardiac activity will diminish as soon as the physiological effects of the drug have passed away.

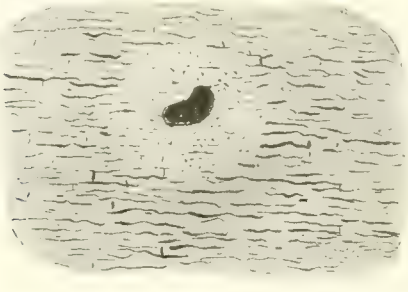

Fig. 3103.—Cardiac Fibrosis and the White Infarct. × 67.

We should also hesitate to give drugs merely for the purpose of lowering or increasing the pulse rate, because the rate may be adapted to the pathological condition. Through the influence of the nerve centers, central or peripheral, there is always a compensatory action of the heart, adapting its speed or pressure, more or less certainly, to varying conditions. Of course, when the acute symptoms have received proper attention no time should be lost in endeavoring to eliminate the toxins (if there has been toxemia) by such means as are calculated to remove or nullify the primary cause of the dilatation.

With our present knowledge of heart block, if it occurs at any time we should suspect myocardial involvement, though not necessarily at the bundle of His (Lewis). Thus far we have no therapeutic resource for it.

Heart failure may, in the absence of myocardial disease, be credited to vasomotor paralysis or paresis. The usual remedies should be employed, of which glonoin and strophanthin stand in the first rank, while in desperate cases artificial respiration may be necessary.

Fat Heart.—Von Leyden's views as to his first two varieties of the fat heart are valuable. In the first of them there may be shortness of breath, asthmatic attacks, and a rapid pulse, even when the heart muscle is not involved, caused by the extraordinary efforts made in the movements of the obese, owing to mechanical interference by the various fat deposits with the respiration and circulation. Such persons seldom live to old age, and succumb very easily to intercurrent infective diseases. This form, however, is curable under appropriate treatment, such as baths, exercises, gymnastics, and diet. But under certain circumstances, such as psychic disturbance, overeating or drinking, or training, it may pass into his second form. In this one (*Russ. med. Rundschau*, 1907, S. 276) the prognosis and treatment are different. The prominent symptom is heart weakness, with precordial distress and orthopnea, while the blood is apt to stagnate in the veins, and there are cough and bloody expectoration, with swelling of the liver. The heart dilates, but the auscultatory sounds vary. The normal sounds are weaker, however, and the apex beat less easily recognized; or there is a splitting of the sounds, or sometimes a systolic murmur at the apex due to muscular weakness at the mitral. The second sound above the aorta is usually stronger than the pulmonary. The action is also arrhythmic. The pulse is small and irregular, but may be slowed or hastened.

When arteriosclerosis is detected in the peripheral vessels, or in the contracted kidney, by uranalysis, we can realize that a fat heart already weak is meeting increased resistance, which must tend to dilatation and heart failure.

The *diagnosis* of fat heart is comparatively easy, though always a matter of inference. It cannot be determined by physical signs. However, as Quain says, in stout people when the pulse is small and weak, the first sound feeble, the impulse weak, and the heart's area enlarged, it may be judged that there is a fat heart, with a fair degree of certainty.

So far as *treatment* is concerned, the condition does not present much difficulty, provided the patient will faithfully carry out some rational plan. A physician, seventy-six years of age, weighing 377 pounds, and unable to walk without assistance, I reduced over forty pounds in a few months, with very little difficulty, relieving his rheumatism and chronic eczema, so that he was able to resume, to some extent, his outside practice. He took several courses of the Nauheim treatment, and adhered to the rigid dietary I laid down. Some, however, women especially, are quite willing to take any prescribed course provided their dietary is not restricted, and treatment with them is consequently a failure.

My dietary avoids fat meat, bread that contains much starch, and coffee, but includes often the use of sodium bicarbonate advocated by Trousseau. I have found that my plan will reduce at the rate of from four to ten pounds a month, a rate that is sufficiently fast. Nor does it preclude tonics, wine, or other stimulants in moderation. As a matter of fact, I have not had occasion to use alcoholics. One of my dietaries is as follows:

8 A. M. Breakfast: Three ounces lean meat without fat; one ounce gluten or whole wheat bread, toasted; a cup of postum with milk, or lemonade.

10.30 A. M. A cup of beef tea.

1 P. M. Luncheon: Five ounces of lean meat or fish; salad with French dressing.

4 P. M. Eight ounces of milk and Vichy water, half and half.

7 P. M. Dinner: Three ounces of rare meat or fish, with pickles or salad; one ounce graham bread, toasted, stewed fruit.

9.30 P. M. Eight ounces of milk and Vichy water, half and half.

Vichy or plain water can be taken as desired during the day. This is not a severe dietary, as compared with some that have been recommended. The general principles under which I practise reduction are restriction in the amount of sugar, starch, and fat eaten, the ingestion of enough water to cause the normal amount of urea to be excreted, and the promotion of oxidation by resistance exercises and by carbonated baths, which stimulate the skin and so improve the capillary circulation. Tea and coffee appear to re-

strict oxidation, and should for that reason, if for no other, be prohibited, or taken in extreme moderation. Acid fruits and drinks should be taken very sparingly. An excess of them produces indigestion. They are better cooked. Sometimes all fruits should be forbidden, but in general small fresh fruits may be eaten with discretion in their season. Sometimes the amount of both liquids and solids has to be much reduced. Laxatives should be taken so as to produce two full fecal movements daily; and stomachics also, if indigestion is acute. The patient should also take regular walks on level ground, of a given distance, and the distance should be gradually increased. Stubborn cases may require the use of the hot box, or some other form of hot air apparatus. With these methods it is practicable to reduce the weight without detriment to the general health. The vitality of the patient should never be reduced; on the contrary, it should constantly increase.

In any case, however, before instituting treatment we should determine whether the fat heart belongs to von Leyden's first or second class, and order the treatment accordingly. Obesity after middle life should be handled with extreme caution. A few years ago a contractor past middle life consulted me for heart weakness associated with obesity. He was leading an active outdoor life. I put him on a restricted dietary, directed him to lead a less active life, and advised him of danger in case he neglected my warnings. He did not visit me again, and within two weeks fell dead while dancing at a ball. This man was to external appearance in robust health, notwithstanding his obesity. The lesson from such a case is obvious. As old age approaches the danger in obesity advances progressively, so that after middle life, as has been said, we should always be cautious in the treatment of these patients.

Fatty Degeneration.—Romberg maintains that coronary disease is the most frequent cause of fatty degeneration, and that the diagnosis of coronary disease as its cause is certain whenever there is angina pectoris or cardiac asthma with sclerosis of the aorta, in a person over forty years of age. In this country most attacks of angina pectoris are held to be of non-organic origin. This is my view. Sclerosis of the aorta cannot always be positively determined during life; and cardiac asthma is common to heart failure in any heart affection.

The first changes of fatty degeneration are of an inflammatory nature, as in typhoid, and are coincident with inflammation of the heart walls. In the first stage, called by some the period of acute myocarditis, the duration is not long (as in the eruptive fevers, typhoid, or other acute toxemias), and there will be present such symptoms as a weak and intermittent pulse, feeble beat, or distant sound at the apex, with faint tones, and more or less dilatation, precordial pain and distress. These signs I noted as early as 1879 in a fatal case of yellow fever that occurred at the Presbyterian Hospital, when I was pathologist to that institution. In this stage the heart may stop; not, however, from the fatty degeneration observed by Hayem in the sudden death of typhoid fever, but from the toxemia, causing defective innervation. For the central nervous system regulates the action of the heart, though it may have nothing to do with its rhythmic activity. To put it physiologically, the contraction and relaxation which characterize the rhythmic action of the heart are due to the interaction of an alternating kind between the sodium, potassium, and calcium ions and the contractile substance of the heart muscle.

In the second stage the signs of a dilated heart are more pronounced. The left ventricle may reach to the left nipple, or extend beyond it; the right ventricle an inch or more beyond the right border of the sternum. The apex may be in the fifth, sixth, or seventh space, and the apex beat feeble. The pulse will usually be soft, intermittent, and infrequent. There may be, and often is, a want of harmony between the heart and pulse beats. These manifestations of arrhythmia are apt to be seen in persons who have passed middle life and are inclined to be stout, but are at the same time anemic. In these cases there is often a distinct whiteness about the face, which is a noteworthy sign. This is common among the upper classes, especially with those who lead a rather inactive life. The apex beat will be located with difficulty, or not at all. There will be dyspnea and some precordial oppression, with occasional attacks of dizziness. Abdominal symptoms will always be in evidence; occasionally gastric crises alternating with anginoid attacks. Cyanosis will occur at times. Such patients will often be irritable or whimsical, or nervous about trifles, and always concerned about their health. There will be a disinclination to undertake anything new, or even to walk, and the gait may be uncertain. Occasionally there will be hemorrhages, usually in the form of epistaxes. Edema of the face, hands, and feet will occur at times. Independent of valve murmurs due to obstruction, there may be systolic murmurs from leakage at the mitral, and if there is hypertrophy of the right ventricle there will be accentuation of the second pulmonary sound. If acute dilatation takes place there will be precordial distress, pain, and dizziness, or a faint feeling. And there will be sharp anginoid attacks, if the dilatation is very acute. If there has been corpulence it will help in the diagnosis; also if there is dyspnea after exertion. Other signs which I regard as very important are: that the apex beat is not to be detected in persons of otherwise normal build, and that the patient must sleep high at night, with several pillows, or resting on his arms. The urine may contain a little albumin and often a little sugar. This stage may last from two or three to ten or fifteen or even twenty years, depending on the degree of the degeneration and the ability of the patient to care for himself intelligently.

In the third stage there is implication of other organs. For example, there may be attacks of cerebral thrombosis or embolism due to abnormal heart action; or thrombosis of peripheral veins; but the circulation may be reëstablished, and the patient resume a tolerably active life. Or, from a variety of causes, perhaps from indigestion, there may come a fatal attack of heart failure. Or, particularly in old people, a low form of meningitis, usually basilar, will develop the Stokes-Adams group of symptoms, with possibly the so-called "heart block." And yet even here the symptoms may yield and life be continued for months or as many as thirteen years, as in one of my cases of the Stokes-Adams type. Finally rupture of the heart may occur. But it must be exceedingly rare. Nephritis is the common terminal affection.

Treatment.—In ordinary cases of fatty degeneration the patient, if anemic, should be put on iron; if tuberculous, on malt preparations and creosote or cod-liver oil; if arteriosclerotic, on the iodides; if rheumatic, on an antilithemic diet and antilithemic remedies, in conjunction with the hot-air treatment. In the first stage, the patient should be treated by rest and an appropriate and rather restricted diet, and general tonics, among which strychnin should have a place. It should be given in small doses, say from one-fiftieth to one-sixtieth of a grain, for adults, and should not be administered continuously for more than two weeks at a time. This, I hold, is important. In the second stage the Nauheim system is appropriate in selected cases. In the third stage, where all hope of cure is at an end, the use of strophanthus and drugs of the digitalis group, the nitrites and nitrates, including glycerol nitrate and erythrol nitrate, camphor, and finally oxygen gas, have each their distinct field of usefulness.

I have been in the habit of employing suprarenal

extract in doses of one to three grains of Armour's powder, in capsules, three times a day, as a substitute for nitroglycerin in the weak heart, and have found it useful, and have observed no bad effects from it. When adrenalin is given in the form of the chloride the dose is usually fifteen minims of a 1 : 1,000 solution, every fifteen minutes, hypodermatically. But in reference to the adrenalin chloride, we must realize that there is a lack of constancy in its action. I recently saw in consultation a patient where, in my opinion, the fatal issue was hastened by adrenalin. Physicians should, therefore, be on their guard against the internal administration of this particular preparation, viz., the adrenalin chloride. Its prompt action in surgical shock should not blind us to the fact that its primary action is followed by a dangerous depression.

In chronic heart insufficiency I am disposed to think well of hypodermatic injections of camphor and oil. Three grains of camphor in seven and one-half minims of oil constitute a fair dose, which may be given every four hours. By keeping these doses in hermetically sealed vials, and using a special syringe, I have never had any abscess, and have used the method persistently for weeks at a time.

A Russian method of treatment, known as the "Karell," or "milk cure," has recently been brought into notice. It consists in limiting the dietary to milk exclusively, and to the amount of about one quart daily. This dietary may be given for four or five days or so, or occasionally, according to indications. Small quantities of milk are taken at short intervals. The rationale of the treatment is that the formation of toxins in the gastrointestinal tract is arrested thereby, flatulence is inhibited, and the heart is relieved of an annoying gastrointestinal pressure either directly or indirectly by causing diuresis. This treatment is claimed to be especially useful in cardiac insufficiency, where there is dyspnea, uremia, or ascites. It also seems to increase the action of digitalis.

Another form of treatment that has come to notice recently is the use of cane sugar. Dingle[10] has reported a case where absolute rest, a careful dietary, and various drugs had failed to benefit a patient with heart failure, and two tappings for ascites had been necessary, but where after cane sugar had been given to the extent of five ounces daily the patient was so much benefited that there was no subsequent need of tapping.

In edema it will be well to limit the amount of salt ingested.

Among other drugs to be mentioned is erythrophlein, or the sassy bark, which is more prompt to slow the pulse than digitalis, though less reliable, and irritating to the stomach. (Wilcox.) Cactus grandiflorus I have used considerably in cardiac insufficiency. I use it in doses of one to two minims of the fluidextract, and have found it efficient in mild cases. Cratægus oxycantha, or hawthorne, has been found by Reilly to be a mild cardiac tonic; he gives ten to thirty minims of a good fluidextract. Convallaria is a heart tonic, but it is unreliable. The use of apocynum cannabinum, or Canadian hemp, has been revived lately. Its active principle, under the name of cymarin tablets (containing each $\frac{1}{200}$ grain) is given in doses of one to three tablets three times a day. It is claimed to be a diuretic as well as a cardiac tonic.

On the whole, chronic heart affections are usually quite amenable to treatment; but the application of the precise remedy requires both experience and skill.

As a final resort in heart failure Bram[11] has used artificial respiration, and reported a successful case. Having been called to a patient with heart failure, he grasped the precordial region with his right hand and made sharp compression of the thoracic walls at the rate of about fifty times to the minute. After about thirty minutes there was a slight response in the radial. Soon the heart began to functionate. After some hypodermic cardiac stimulation there was a fair pulse in five hours. In my own experience I have resuscitated a patient whose pulse and respiration had stopped by using my method of reviving the apparently drowned, a method applicable also in suspended respiration under ether anesthesia. Placing my hand under the abdomen, I pressed against the heart by crowding stomach and intestines against it, making pressure gently at first and about four times in a minute, then gradually increasing to sixteen. The suspended pulse and respiration slowly returned, so that in an hour the patient was out of danger. It is well also to slightly irritate the surface of the chest over the heart, as Abrams has shown that it causes cardiac contractions.

Prognosis.—With regard to prognosis in myocardial disease, we must assume from analogical reasoning, together with clinical experience, that parenchymatous changes, if not excessive, can disappear with convalescence; and yet by analogy we must equally well hold that they can lead up to acute diffuse myocarditis, and may also terminate in fatty degeneration. In very many cases, however, as far as we can determine by clinical tests, the patients recover entirely. The same process of reasoning leads us to believe that even in acute interstitial disease the fibroid deposits may wholly disappear. In tuberculous myocarditis there may be a disappearance of all signs of the tubercles, as in tuberculous peritonitis. The same may be said of syphilis. Moreover, a moderate degree of fatty degeneration is present in almost every adult heart, and if a postmortem examination displays the so-called "tiger's heart," where the striations of fatty degeneration show in places through the transparent endocardium, one would hardly call it abnormal. The prognosis in cardiac syphilis is not altogether bad; if the diagnosis is made early and the proper treatment instituted success may be expected. Even in advanced cases, where there is tabes dorsalis, for example, great improvement can sometimes be effected. Iodides and mercury are the proper remedies, but mercury is the sheet anchor. Salvarsan of course is useful, but is not as valuable in chronic as in acute cases, and should be combined with mercurials. Sometimes the remedies should be given for months, with brief interruptions of a few weeks.

It should be remembered that there are persons whose hearts functionate sufficiently well until they are subjected to some special strain, physical, mental, or psychic, when the insufficiency becomes apparent. Often a few steps about a doctor's office is all that is required. To determine the amount of this weakness various methods have been tried for more than a century. In fact, the determination of the functional capacity of the heart is a matter of very great importance, not only from the point of view of diagnosis, but for the purpose of controlling the effects of treatment. But the methods used have been open to so much criticism that internists have usually given the subject a pretty wide berth. The first material advance was made by Spengler, in 1887, when he noted the effects of exercise and change of posture on the pulse of typhoid-fever convalescents. Of all the methods proposed, three may be taken as examples of the most recent that have been published. Katzenstein's, published in 1905, consists in compressing the femorals or iliacs below Poupart's ligament and noting the effect on the brachial artery. In healthy persons he has claimed an average rise of five to fifteen millimeters Hg in from two to five minutes, as shown by the sphygmomanometer. In weak hearts, he has reported that the pressure either rose slowly or not at all, or fell, according to the grade of weakness present. As to the accuracy of this method, reports have differed. In acute cases it is of course inapplicable.

Compression of these vessels is not an easy task; an assistant is necessary to take the pulse. In ordinary private practice, a patient might very reasonably object to the procedure. Graupner's method[12] consists in testing the pulse before and after definite physical exertion, such as walking rapidly around the physician's office. In the efficient heart the pulse should rise rapidly during the exercise and then gradually return to the former rate. The blood pressure should also rise, returning to the former register somewhat more slowly than the pulse. Inefficient hearts either fail to react at all, or only slightly. The older method of Schapiro[13] is another good one, which should be practised more than it is. The pulse is first taken in the recumbent and then in the sitting position. In health there is an increase of frequency when the individual assumes the sitting posture after lying down, of from three to ten beats per minute. In the weak heart there is an absence or a diminution of this frequency on changing from the recumbent to the sitting position. I have used this method for several years, with a fair amount of success. For ordinary purposes we have no better methods than these two latter, and, inasmuch as they are simple, practical, and fairly reliable, it is advisable to use one or the other to test the functional capacity of the heart, until something better is presented.

THOMAS E. SATTERTHWAITE.

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Heart, Neoplasms of the.—Primary tumors of the heart are very rare. They may arise in the myocardium, or in the peri- and endocardium, from which points they may invade the heart muscle. They may also take their origin from the valves. They may be single or multiple. They may form nodular circumscribed masses in the heart wall, or project as polypoid growths into the heart cavity. Only rarely do they form diffusely infiltrating growths. Many are of congenital origin. The majority of cases occur in young or middle-aged individuals; a few have been found in old age.

Primary tumors of the pericardium are very rare. Fibroma, myxoma, and pedunculated lipoma have been observed. Metastatic sarcoma (lymphosarcoma, round-cell sarcoma, spindle-cell, chondro- and osteosarcoma) and carcinoma (malignant hypernephoma) are more common. They appear as disseminated nodules or diffuse infiltrations of the pericardium, often resembling pericardial thickenings due to inflammation. A hemorrhagic pericarditis is usually associated (pericarditis carcinomatosa hemorrhagica). The presence of areas of caseous necrosis may lead to an incorrect diagnosis of tuberculous pericarditis. Microscopic examination may be necessary to fix the diagnosis.

The *myxoma* is the most frequent variety of primary neoplasm of the myocardium, a number of cases having been observed. Of these the majority were pure myxomata, the others fibromyomata. In one case the growth was described as an angiectatic myxoma. As a rule they form polypoid growths projecting into the heart cavities. It is very doubtful, however, if some of the polypoid formations found on the endocardium were really of the nature of neoplasms; rather is it probable that they were masses of newly formed connective tissue of myxomatous type resulting from the organization of thrombi. The writer has found myxoma-like formations in the heart-wall containing great numbers of treponema pallidum (congenital syphilis). They must be interpreted as mucoid gummas. In a case of fibromyxoma of the left auricle occurring in a girl of four years, Jacobsthal found large numbers of newly developed fibers of yellow elastic tissue. In the majority of cases the myxomatous tumor has been found in the left auricle, very often being attached to the endocardium by a slender pedicle. Papillary myxomata have also been found upon the tricuspid flaps.

Next in order of frequency of the primary cardiac neoplasms is the *rhabdomyoma*. Its peculiar histological structure gives to it a great interest. Cases have been described by von Recklinghausen, Virchow, Hlava, Kolisko, Cesaris-Demel, and Seiffert. The tumor is of congenital origin, and is usually multiple. The nodules are not encapsulated, but are well outlined from the cardiac muscle, and quite sharply demarcated from the pericardium and endocardium. The growths may be as large as walnuts, and are scattered through the ventricular walls and the interventricular septum. On section the nodules are reddish-gray in color. The microscopical appearances are very striking. Trabeculæ of varying thickness showing transverse striations are arranged so as to form small spaces. These spaces do not communicate with each other; they contain large polygonal cells of irregular outline having one or more oval nuclei which are centrally situated. Their protoplasm shows a faint striation. In some cases the cell appears to form part of the wall of the space and sends prolongations across the latter. Both the protoplasm and prolongations of these cells stain like muscle. The fibers resemble in all respects those of the bundle of His. The spaces and their contents have received very different interpretations from the different observers who have studied this tumor. Hlava regarded them as intracellular, Kolisko as intercellular. According to Seiffert each space and its wall represents a greatly enlarged embryonal heart-muscle cell. The smallest tumor nodules may consist of bundles of delicately striated fibers only, without the peculiar spaces. Of the significance and mode of formation of the cardiac rhabdomyoma we as yet have no satisfactory explanation. It is a striking fact that in many of these cases of cardiac rhabdomyoma there is an associated hypoplasia of the cerebral cortex and malformation of the kidneys.

Primary *sarcoma* of the heart is much more rare; and it is very probable that some of the cases diagnosed as such were secondary to some undiscovered focus elsewhere in the body. The reported cases have been in both young and old individuals. The varieties observed were round and spindle-cell forms, myxosarcoma, fibrosarcoma, and angiosarcoma.

Cases of primary *fibroma* of the heart have also been reported, but the true nature of these cases is uncertain. It is quite probable that they represent organized thrombi. Observations have also been made of the primary occurrence of *lymphadenoma*, *lymphangioma*, *cavernous myoma*, *cavernous angioma*, and *lipoma* in the heart. They are found particularly in the wall of the auricles, especially the left. Some of the descriptions given in the literature are very unsatisfactory, and undoubtedly many of these so-called tumors were either thrombi in various stages or young gummas. The polypoid *cysts* which have been described by a number of writers as primary cardiac neoplasms are without doubt to be regarded as degenerating or partly organized polypoid thrombi. They are found most frequently in the left auricle, are reddish-gray in color, and have a smooth shining sur-

face. On section they show a cystic space filled with the products of the simple softening of the central portion of the thrombus. When organization of the periphery of the thrombus has begun the resemblance to a true cyst is very close.

Primary neoplasms of the valves are more rare than those of the heart wall. A *papillary myxoma* of the posterior tricuspid flap, *multiple myxomata* of the size of peas of the same valve, and *spindle-cell sarcoma* of the pulmonary valves have been reported. The possibility of incorrect diagnosis must again be urged here. The great majority of myxoma-like formations upon the valves are organized thrombi or polypoid proliferations of the elastic layer of the flaps due to mechanical causes. They are very common in old people, particularly on the noduli Arantii of the arterial openings.

Secondary neoplasms of the heart are also rare but much more frequent than the primary. Secondary *carcinoma* is the most common tumor of this organ (carcinoma of kidney, thyroid, esophagus, bronchus, mamma, etc.). Primary cardiac cancer is of course an impossibility, though in the older literature descriptions of growths regarded as such are found. These cases were either cancer-secondaries, or, as was not infrequently the case, sarcomata were diagnosed as carcinomata. Secondary carcinoma of the heart may arise through metastasis, or by extension through continuity or contiguity through the pericardium from carcinomatous growths in the lungs, esophagus, or secondary deposits in the mediastinal lymph glands. Metastatic carcinoma of the heart may arise from emboli of cancer cells in the coronary vessels, on the mural endocardium, between the papillary muscles, and on the valves. From a secondary focus thus formed further extension may take place through the cardiac lymph channels. In this manner diffuse carcinomatous infiltration of the entire cardiac wall may take place. In other cases multiple metastases in the heart may be found. These may be found in the walls of both auricles and ventricles. There does not appear to be any favorite seat of deposit. In the majority of cases the carcinoma is of the medullary type. In the event of carcinomata breaking into the vena cava large emboli of carcinomatous tissue may be carried to the right heart where they may become attached to the endocardium or develop as free carcinomatous masses.

Secondary *sarcoma* of the heart, while less common than secondary carcinoma, has been observed by a number of writers (lymphosarcoma, round-cell sarcoma, melanotic, osteo- and chondrosarcoma). The growths are usually metastatic, but the heart may be involved also by extension through the pericardium from primary mediastinal sarcomas. The tumors may be single or multiple. They may be nodular, diffusely infiltrating, or in the form of flattened plate-like growths more or less sharply outlined. Free sarcomatous masses may be found in the right heart in cases in which the primary tumor has invaded a large vein. In a case described by Osler of sudden death in a child the tricuspid orifice was found blocked by a sarcomatous mass coming from the renal vein. In a case of primary sarcoma of the nose reported by the writer the entire heart wall was found to be infiltrated with sarcoma, while in the right ventricle there was a free sarcomatous mass of the size of a walnut. Leukemic infiltrations, particularly in lymphatic leukemia, are not rare in the myocardium.

Small tumors of the heart may produce no symptoms; larger growths may lead to cardiac hypertrophy, dilatation, valvular stenosis or insufficiency, rupture of the heart wall, secondary embolism, etc. As the result of injury to the bundle of His from the development of tumor nodules in the septum the patient may show the Adams-Stokes symptom-complex with dissociation of auricle and ventricle. An absolute diagnosis in the majority of cases is impossible. In suspected cases the Röntgen ray might reveal changes of size or form in the heart. If the pericardium is involved and a pericardial exudate present, some of the latter should be withdrawn for examination. The presence of a hemorrhagic exudate would be regarded as favoring the presence of a malignant tumor. Of greater diagnostic significance would be the character of the cells found in the exudate. The presence of numerous mitoses in these, particularly atypical mitotic figures, could be taken as almost positive evidence of the presence of malignancy. The treatment is wholly symptomatic.

ALDRED SCOTT WARTHIN.

Heart, Neuroses.—See *Heart, Functional Disorders of.*

Heart, Pericarditis.—See *Pericardium, Disease of.*

Heart, Physiology.—See *Blood, Circulation of.*

Heart, Rupture of the.—This accident, while quite rare, is doubtless more frequent than is commonly supposed inasmuch as many cases of sudden death (in which there is no suspicion of foul play) are diagnosed as heart failure, or apoplexy and no autopsy is held, so that the actual condition of the heart is not ascertained. Devergue asserts that in every forty cases of sudden death there is one due to rupture of the heart. Heart ruptures may be divided into two classes: *First*, Those due to degeneration of the myocardium, the so-called spontaneous ruptures; and *second*, those due to traumatism.

Instances of the first class, while not frequent are more often observed than are those of traumatic origin.

MORBID ANATOMY.—Spontaneous rupture of the heart generally occurs in the substance of the left ventricle owing to the greater frequency of degenerative changes in this locality, and to the greater strain which this part of the heart has to bear in lifting the blood through the systemic circulation.

The anterior face of the ventricular wall somewhat above the apex is usually the site of the tear. Although it is said that the rent usually begins from within and proceeds to the outer face, the reverse may happen, and it is generally impossible to tell from inspection upon which surface the lesion originated. The sites of the rupture in 55 cases collected by Elleaume were as follows: 43 in the left ventricle, 7 in the right, 3 in the right auricle, and 2 in the left auricle.

The rupture may be complete or incomplete, and may vary in extent from a centimeter to the length of the ventricle. It is usually single, but as many as five tears have been noted, in one heart wall, sometimes intercommunicating. The rent is generally ragged, irregular, and sometimes ecchymosed at the edges. Its course through the ventricular wall may be tortuous so that the endocardial and epicardial openings do not correspond. Usually the fissure runs parallel to the course of the muscular fibers. Those ruptures which are due to an abscess of the heart wall or to hemorrhagic softening or to a gumma, more frequently are in the form of an ulceration or perforation. The immediate result of this accident is the distention of the pericardial sac with blood which generally forms clots, which with the serum are found in the pericardium.

Cases have been noted in which a plug of fibrin has more or less completely occluded the tear in the heart wall.

ETIOLOGY.—This form of rupture is always the result of disease of the myocardium, softening, fatty degeneration, fatty infiltration, or gummata of the cardiac wall, etc. The degeneration is most frequently dependent upon occlusion or fibrosis of the coronary arteries. This degeneration may be local or general,

and may result primarily in an aneurysm of the heart or aorta, which may burst. Osler says (Prin. and Prac. of Med., 1912, p. 830) that there was rupture in seven of the ninety cases of aneurysm of the heart wall collected by Ligget. Very rarely we have abscess of the heart wall, which bursts and leads to rupture. The *exciting* cause of the lesion may be a sudden and perhaps an unusual motion like stumbling or falling, lifting or straining. A comparatively frequent cause in civilized countries is running for a railroad train. Milne (*Indian Med. Gazette*, Sept., 1912, p. 356) mentions two cases of rupture of left ventricle and thinks that heart ruptures are not uncommon among hill coolies who carry prodigious loads uphill. A case is given of the rupture of the right ventricular wall in a "rickshaw" coolie simply from overexertion. Anger, excitement, and mental or physical shock may determine the accident. Not infrequently it occurs while the patient is in perfect rest. He may be asleep in bed. The male sex is considerably more liable to this accident than the female. It seldom occurs before the fiftieth year, more often after the sixtieth. Schaps (Osler, Prin. and Prac. of Med.), reports a case of rupture of left ventricle in an infant of four months due to embolic infarction.

Symptoms.—Seldom are the premonitory signs of this disaster distinctive. There would naturally be signs of a diseased and feeble heart. Comparatively few diseased hearts, however, go on to rupture. On the occurrence of the lesion, death is usually instantaneous; the patient not infrequently being found dead in bed with the clothes not even disturbed. In case the rupture is oblique in direction and small in extent, the patient may survive several hours or even days.

Dr. Langman has recently reported a case of a man who had two ruptures of the heart wall, one having happened two weeks before the other. He died four hours after the occurrence of the second, which was in the left ventricle, the first was in the right. The heart walls were thin, but not fatty.

The special symptoms denoting approaching dissolution are intense precordial pain, restlessness, dyspnea, rapid, feeble, and fluttering pulse; vomiting, cyanosis, loss of consciousness, and convulsions.

Hampeln has observed that there is greater pain in rupture of the pericardial portion of the aorta than in that of the heart substance proper.

The physical signs, even when the patient's life is sufficiently prolonged for them to be observed, are more or less indefinite. The pulse is weak and intermittent. The heart sounds are muffled, distant, and imperfectly developed, with probably some increase or pericardial dulness.

Diagnosis.—This is so uncertain that it cannot as a rule be relied upon, although in some cases the condition has been made out ante mortem. A diagnosis ought certainly to be made in those cases in which, in addition to the rational symptoms already detailed, percussion affords evidence that the pericardial area has recently undergone enlargement.

Prognosis.—This is uniformly unfavorable; no case of spontaneous heart rupture having ever been known to recover, although life may be prolonged for several days and even weeks, by judicious treatment and nursing.

Treatment.—This is mainly palliative and can have no effect on the diseased condition of the heart. Cold applications, morphine hypodermatically, a strict maintenance of the recumbent posture, perfect quiet, and warmth to the extremities may prolong life for a limited period. Stimulants are contraindicated and so are operative procedures; even if the patient had sufficient vitality to justify an attempt to suture the heart wall the diseased myocardial tissue could not be expected to hold the stitches.

Traumatic ruptures, as distinguished from gunshot and stab wounds of the heart, are quite rare. This organ from its shape and position, its mobility and the protection afforded it by the elasticity of its walls, and by its overlying and surrounding structures, is seldom ruptured by traumatism—except in cases in which the chest wall is crushed in. A certain number of cases of rupture of the heart walls have occurred with comparatively little injury to the chest wall, and often without penetration of the pericardial sac. The writer was able, some years ago, to collect forty-five cases of heart rupture, not due to stab or gunshot wounds, and generally speaking caused by an injury from the effects of which the heart walls would be expected to escape scot free. In the majority of these cases however there was evidence of pre-existing disease or abnormality of the organ. But in a few cases the heart muscle was healthy.

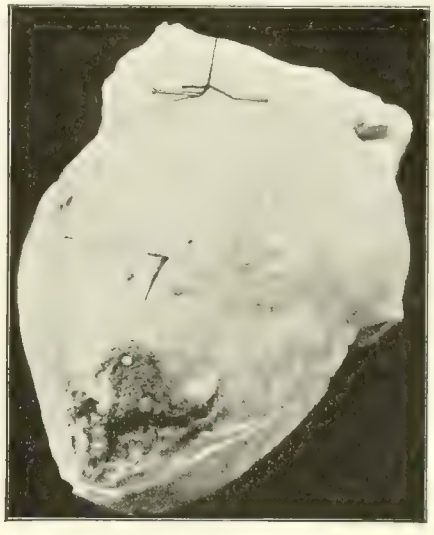

Fig. 3104.—Showing Traumatic Rupture of Heart at Apex of Right Ventricle.

The writer reported the case of a vigorous man of twenty-eight who was riding his bicycle rapidly, when the forward wheel struck a hose pipe which was filled with water and which lay across the road. As a result of this sudden strain the bicycle broke at the "head," and the rider was thrown to the ground with great violence, the detached handle-bar post interposing itself between his body and the hard road. This impact fractured the sixth costal cartilage somewhat to the left of the sternum and drove the distal end, attached to the rib, into the pericardial sac. The sac did not tear; but the force of the blow was so great that the right ventricle was torn entirely through. A triangular flap (Fig. 3104) of the heart wall had been lifted up, and when it was turned back the ventricular cavity was exposed. The heart weighed eleven and one-quarter ounces, and its valves and muscular substance were healthy and competent. The man lived for an hour and a half after the accident and partly recovered from shock. The cause of death was apparently the distention of the pericardium with blood, of which from eight to ten ounces, mostly coagulated, was found in the sac.

Of traumatic ruptures a majority occur in the right ventricle near its apex. Of Gamgee's 28 cases, in 9 there was no fracture of ribs or sternum and either no bruise of the parietes or a very slight one. The

pericardium was intact in at least one-half of the cases, and in 22 in which the principal seat of the injury was noted, the right ventricle was torn in 8; the left in 3. The left auricle was injured in 7 and the right in 4. The apex of the right ventricle is a favorite spot for traumatic rupture, first, on account of its exposed position as it comes in contact with the chest wall in systole, and second, because the myocardium is thinnest at this point. Ruptures of the muscular fibers most frequently occur in systole when they are tense and firm and offer the greatest resistance to the impact of the opposing force. If ruptured in diastole when the ventricles are filled with blood, their walls being flaccid, the seat of rupture will be in the resisting valves, or in the interventricular septum.

The symptoms of intense pericardial pain, weak, fluttering or intermittent pulse, dyspnea, lividity, cold extremities, sweating, and convulsions, are much the same as in cases of spontaneous rupture. With the history of a blow upon the chest, especially if the ribs or their cartilages are found fractured, the diagnosis of heart rupture might be made out and bold surgery might save a life. No other treatment could be anything more than palliative.

Richard Cole Newton.

Heart, Sounds of.—See *Cardiac Murmurs.*

Heart, Surgery of the.—See *Heart, Wounds of.*

Heart, Syphilis of the.—That syphilis plays a very important part in the etiology of cardiac affections has long been suspected by both clinicians and pathologists, although the amount of evidence afforded by the literature is very small. Many text-books still say that cardiac syphilis, particularly the congenital form, is not common. Before the discovery of the spirochete the pathologist himself was able to recognize but few lesions of the heart absolutely pathognostic of syphilis. The gumma could be safely recognized as syphilitic, but cardiac gummas are not common; and the assumption that certain forms of chronic myocarditis, fibroid heart, coronary sclerosis, cardiac infarction, aneurysm, etc., were syphilitic, because they were found so often in connection with other lesions of syphilis rested upon purely circumstantial evidence until the discovery of the spirochete gave a positive criterion for the pathologic diagnosis of syphilis.

Recent studies of cardiac syphilis (Warthin) show that the primary lesions produced in the heart by the *Spirochæta pallida* may be either *parenchymatous* or *interstitial.* The parenchymatous lesions are a peculiar pale degeneration, fatty degeneration, simple atrophy and necrosis; the interstitial lesions are the occurrence of a peculiar form of edema (myxedema), vascular and perivascular infiltration, interstitial myocarditis, gummas, and localized myxoma-like formations. Localized infiltrations and gumma-like proliferations occur also in endocardium and pericardium. The parenchymatous changes may occur absolutely independently of the interstitial, and the latter may be found with no associated changes in the neighboring heart muscle. The more marked the interstitial changes, the more likely are parenchymatous changes to be associated with them; but the most marked parenchymatous lesions occur without any interstitial changes. The purely parenchymatous lesions are found especially in virulent congenital and active secondary and early tertiary syphilis; in milder and older infections the interstitial changes, particularly the localized vascular and perivascular proliferations, predominate. The myxoma-like formations resembling undifferentiated gummas also occur in more localized and milder infections.

It is of very great importance to know that the heart is so frequently the seat of spirochete localization. The cardiac localization of spirochetes has been found to be more common even than the hepatic. Spirochetes may be found in great numbers in the heart when no others can be found elsewhere in the body. In such cases the cardiac muscle may show at times no lesions that, according to the older knowledge, would be classed as syphilitic, indeed, no other organ or tissue may show any histologic signs of syphilis even when the organisms are present in the heart in great numbers. That syphilis can produce purely parenchymatous lesions primarily in the myocardium opens up greatly the possibilities of this infection as a factor in the increasing myocardial affections of unknown origin. To what extent the *Spirochæta pallida* is the etiological agent in these latter conditions cannot be estimated with certainty at the present time, but it is becoming more and more probable that syphilis, both congenital and acquired, is one of the most important factors in the production of cardiac disease, both myocardial and endocardial.

Congenital Syphilis.—*Parenchymatous Lesions.* 1. *Localization of Spirochetes in the Myocardium without Recognizable Tissue lesions.*—Large colonies of spirochetes may be found in the myocardium, either in the tissue spaces of certain muscle areas, or about the blood-vessels, without any changes in the neighboring heart-muscle that can be recognized by any of the technical methods employed at the present time. The muscle stains as well as normal heart-muscle, it contains no vacuoles or granules, and presents all the appearances of normal muscle. The spirochetes lie in the intermuscular spaces, often in great numbers. Sometimes they appear within the muscle-substance, as shown in cross-sections, but this is not common.

2. *Pale Degeneration of the Heart-muscle in Association with Spirochæta Pallida.*—One of the earliest recognizable changes in the heart-muscle in areas containing spirochetes is the loss of color in the muscle-fiber and its failure to take eosin in the normal way. Compared with normal areas such affected muscle appears very light and clear, with a loss of its striations, and shows vacuolated or light-staining nuclei. In the severe grades of this change the muscle passes so insensibly into the connective tissue that it is difficult to separate the two, so closely do they come to resemble each other in ordinary stained sections. Vacuoles may or may not be present in these fibers. The appearance of the fiber is not wholly like that of Zenker's necrosis, as it is less waxy or hyaline, appearing "washed-out." The fibers are also smaller than normal. This form of degeneration may occur as a purely parenchymatous change, but is most commonly associated with interstitial changes, particularly with the mucoid edema so frequently seen in congenital cases. This change is probably to be interpreted as being of the nature of a serous atrophy or liquefaction necrosis, but there is never any fraying-out of the cell protoplasm as in ordinary liquefaction necrosis.

3. *Fatty Degeneration.*—A marked fatty degeneration of the cardiac muscle is often the only tissue-lesion associated with the presence of the spirochete colonies in the myocardium. It occurs as a focal change, visible to the naked eye as yellowish pin-head spots, but often larger. Microscopically, the fibers are atrophic and filled with large droplets of fat, the droplets as a rule being larger than those commonly seen in fatty degeneration of the heart muscle in such conditions as anemia, phosphorus poisoning, etc. Usually two or three large vacuoles replace the cytoplasm. This fatty degeneration of the fibers occurs also in the muscle surrounding the areas of interstitial infiltration and proliferation. In these areas of fatty degeneration fewer spirochetes are usually found than in the focal areas of fatty degeneration unaccompanied by interstitial changes. In the case of severe vascular and perivascular infiltration and proliferation irregu-

lar areas of fatty degeneration occur along the affected areas, but this is probably a secondary change to the circulatory disturbance. In the focal areas without other changes than the mere presence of the spirochetes, the occurrence of the fatty change must be explained as due to the presence of the organism—the latter probably robbing the tissues of their oxygen and food supply. Following the focal fatty degeneration there may occur later a deposit of lime salts, so that focal areas of calcification can be produced by syphilis, and their occurrence should lead to a suspicion of this infection.

4. *Simple Atrophy.*—Colonies of spirochetes can sometimes be located by the presence of focal areas of simple atrophy, the muscle showing no other change than a marked reduction in size. The interstitial substance may or may not be increased or show proliferation, and the pale degeneration and fatty degeneration may be associated with the atrophy.

5. *Necrosis.*—In virulent cases of congenital syphilis in which the tissues of the body show enormous numbers of spirochetes, yellowish or light-colored areas may be found in the myocardium as well as in other parts of the body. These areas rarely exceed five millimeters in diameter, and are usually much smaller. In the heart the muscle in these areas appears as fine fibrillæ without nuclei, or is entirely absent, its place being taken by a collection of lymphocytes, plasma cells and fibroblastic cells. Around the borders fibers showing transition stages of liquefaction necrosis are seen, and the surrounding tissue appears as in a chronic edema, the tissue-elements being pushed apart, and the spaces filled with a fine albuminous precipitate, a mucoid substance and cells. With the specific mucin dyes, as cresyl violet, reactions for mucin are almost always obtained in these areas of liquefaction necrosis. Such changes may be absolutely independent of any vascular changes, and are wholly the result of the spirochetes that lie packed in great numbers in these necrotic areas. Vascular changes may, however, be associated with such focal necroses.

Interstitial Changes.—1. Edema.—In the hearts of congenital syphilis pale areas, moist and translucent, may be seen even with the naked eye, or the entire heart wall may be very pale, translucent and moist. On microscopical examination the pale foci are found to be areas in which the changes are wholly suggestive of edema. The muscle fibers are pushed apart, the reticulum is fibrillated and contains fine granules, the number of wandering cells more or less increased. The presence of fat vacuoles in the muscle fibers adds to the general picture of a severe local edema, so that the average observer would pass it as an edema. But the Levaditi preparations show these apparently edematous areas to be filled with spirochetes, and the mucin tests show very frequently the presence of a mucin-like substance, so that the edema is more of the nature of a myxedema. In these areas the spirochetes often appear closely applied to the capillary walls. Some of these areas are relatively poor in cells, but the majority show a fibroblastic proliferation, large pale epithelioid cells occurring, their cell bodies lightly staining and their whole appearance washed out. Mononuclear white cells, plasma cells and lymphocytes are present in varying numbers; and every transition exists between these pale, non-cellular watery areas and those containing many cells.

2. *Interstitial Proliferation.*—This may occur as the first recognizable tissue lesion, but usually after it has reached a certain point the parenchyma shows degenerative changes also. In the heart the proliferation appears to be always primarily vascular or perivascular, the endothelial cells of the capillaries proliferating and forming rods and groups of pale epithelioid cells, the capillary becoming thicker and thicker as the mass of cells in its walls increases. Now capillaries are produced and the area may come to be highly vascularized, but the new vessels are quickly obliterated by the proliferation of the wall. In the larger vessels, particularly in the arterioles, the proliferation is almost wholly perivascular and the spirochetes are found in great numbers in the perivascular lymphatics. Later these areas may become fibroid, and every possible transition stage is found between the focal edemas and the areas of proliferation that may be interpreted as non-caseating gummas when sharply localized. In the congenital syphilis cases caseation of these areas must be very rare, as I have never found it. Such areas of proliferation without caseation exist also in acquired syphilis.

3. *Myxoma-like Areas.*—A very striking finding in the hearts of congenital syphilis is the occurrence of round translucent areas that microscopically suggest myxomata and have been mistaken for such. With ordinary stains, hematoxylin and eosin, they appear as sharply circumscribed spherical areas in which the heart muscle fibers have practically dispapeared, only a few atrophic fibrillæ being left. A gelatinous tissue containing branching epithelioid cells and lymphocytes forms the main part of the area, and new capillaries occur in it. Mucin tests show the presence of a large amount of mucin, so that the resemblance to a myxoma is greater still in preparations stained in this manner. Levaditi preparations show the presence of spirochetes in varying numbers in these areas, although the number is usually not so great as in the focal fatty areas and edemas. It is probable that the infection is a less virulent and more sharply localized one. These areas may be regarded as young or undifferentiated gummas—myxogummas—without fibroid change or caseation, the tissue remaining in fibroblastic semi-gelatinous state. The infiltration of lymphocytes is often very slight, so that if the Levaditi stain be not used for the demonstration of the spirochetes, the true nature of the process would not be suspected.

4. *Gumma.*—Typical caseating gummas have been described as occurring in the hearts of congenital syphilis, but they are not common. They have presented appearances similar to those seen in acquired syphilis. The wall of the right ventricle is said to be more frequently affected than the left.

5. *Endocardial Lesions.*—Fibroblastic proliferations and infiltrations of the endocardium occur in congenital syphilis. Fibrous thickenings of the valves or parietal endocardium may result (sclerosis). Valvular lesions may result; the aortic and pulmonary valves are most frequently affected. Syphilitic lesions of the endocardium may favor the occurrence of infections of the valves with the progenic organisms, thus causing valvular lesions. Thrombosis is a direct sequel of the syphilitic changes in the endocardium; and some of the pedunculated myxoma-like polyps of the heart-wall may be of syphilitic origin.

6. *Pericardial Lesions.*—The pericardium is less frequently affected in congenital syphilis than the endocardium, but localizations of spirochetes occur in the subserous tissues giving rise to lymphocyte infiltrations, fibroblastic proliferations and myxoma-like formations. Some, at least, of the pericardial scleroses ("soldier spots") are the result of healed congenital syphilitic lesions of the epicardium.

Acquired Cardiac Syphilis.—Acquired syphilis of the myocardium may manifest itself in the form of a local or diffuse parenchymatous or interstitial myocarditis or as a gummatous myocarditis. The interstitial induration is by far the more common process; it may be the result of the direct action of the spirochetes or secondary to a syphilitic endarteritis.

In acquired syphilis, as well as in congenital, colonies of spirochetes may be found in the myocardium, at times without any apparent change in the heart muscle; or they may produce purely parenchymatous lesions (fatty degeneration, pale degeneration,

atrophy, etc.). All stages of parenchymatous and interstitial lesions may be found in acquired syphilis, as in the congenital infection, although the earlier myocardial lesions of acquired syphilis are rarely seen, except in syphilitic cases dying from some other cause. Systematic examination microscopically of the hearts of relatively recent syphilitics and of those in early tertiary stage shows, however, a very high frequency of parenchymatous and interstitial myocardial lesions associated with the localization of spirochete colonies.

In its earliest stages the interstitial change is found as a cellular infiltration along the small vessels of the intermuscular connective tissue. Fibroblastic proliferation occurs in the latter, leading gradually to the formation of small scattered nodules of granulation tissue, which soon become converted into scar tissue. In the fibroid areas thus formed remains of degenerated muscle, pigment, fat droplets, etc., are found. The newly formed fibrous tissue may undergo caseation or become calcified. The neighboring muscle shows extensive atrophy and fatty degeneration. When the spirochetes are present in great numbers the interstitial changes may be myxomatous in character as in congenital syphilis. A mucoid change is not uncommon in the perivascular proliferations of acquired syphilis. Such areas always indicate the presence of large numbers of spirochetes. In other cases the cellular infiltration is in the form of bands or sheets running parallel with the axis of the muscle bundles. These may or may not be sharply defined; usually the new tissue sends out fine prolongations into the neighboring muscle. As the cellular infiltration develops it becomes gradually changed into a coarse hyaline variety of fibrous tissue containing few nuclei. Through atrophy of the intervening muscle the bands of connective tissue gradually coalesce and may come to make up the entire thickness of the heart wall from pericardium to endocardium. The left ventricle, the anterior wall, the apex, and the septum ventriculorum are most commonly affected, the papillary muscles and the walls of the auricles only rarely.

In many cases the fibroid change is directly dependent upon the presence of an obliterating endarteritis in the coronary arteries. Complete occlusion of a terminal branch produces anemic infarction, the necrosed muscle being replaced by scar tissue; slowly progressive obliteration of the vessels leads to degenerative changes in the muscle with secondary inflammation and proliferation of the interstitial tissue. To the naked eye the fibroid areas appear as white, glistening, tendon-like bands or masses. The weakening of the heart wall, due to the inability of the new connective tissue to contract against the intracardiac pressure, often leads to an aneurysmal dilatation at the point of greatest change. Thrombosis of the left ventricle is practically always the result of syphilitic lesions of the heart wall.

The gummatous form of myocarditis is of much less common occurrence. It is usually associated with a more or less diffuse interstitial change. It is probable that in many cases the fibroid myocarditis found at autopsy is the result of antecedent gummatous processes. Gummata may be found in any part of the heart wall, in the myocardium, or beneath the peri- or endocardium. Their favorite location is in the auricular and ventricular septum, very frequently affecting the main trunk of the bundle of His. To the naked eye they appear as yellowish or grayish cheesy nodules, varying in size from a mustard seed to a walnut, and are usually surrounded by a dense fibrous capsule. Fresh gummata are red or pink in color and of a soft homogeneous structure. They do not possess a fibrous capsule and are not sharply outlined from the surrounding tissue. Usually the heart gummata are solitary, but in many cases multiple caseous nodules are found scattered throughout the cardiac wall. When the gumma is located just beneath the peri- or endocardium chronic adhesive pericarditis and sclerosis of the endocardium are usually present. Hypertrophy and dilatation of the heart are frequent secondary changes dependent upon the myocardial condition. On microscopical examination the gummata of the heart are distinguished from those in other regions of the body by the cellular nature of the process, the rarity of giant cells and the relatively slight degree of caseation. The myxogumma is rare in acquired syphilis, and, when found, shows the presence of enormous numbers of spirochetes. In the caseating gummas they are usually few in number, and often cannot be demonstrated. Obliterating endarteritis of the coronary arteries may or may not be associated with gummatous myocarditis but usually is.

The involvement of the coronary arteries plays a very prominent part in the pathology and symptomatology of cardiac syphilis. Two types of vascular syphilis occur, sometimes distinct, but usually associated: obliterating endarteritis and proliferative periarteritis. The former is the more common in acquired syphilis, the latter in congenital; but the spirochetes have an especial predilection for the perivascular lymph spaces, so that frequently enough they are found colonized around the coronary vessels in acquired syphilis, producing the same changes as those found in congenital cases, although the fibroid stage is the one usually seen at autopsy. It is always easier to demonstrate the spirochetes in the perivascular proliferations than in the intimal. As a result of the nutritional disturbance arising from the coronary changes the myocardium receives perhaps as much damage secondarily as it does primarily from the spirochetes. It is also possible that the lowered nutrition resulting from the vascular changes makes the muscle more susceptible to the spirochete. Nevertheless, the most severe myocardial changes may exist without any apparent change in the coronaries down to the smallest arterioles but changes in the latter are always present except in the pure parenchymatous lesions caused by the spirochetes.

Scleroses of the *epicardium* are very common in acquired syphilis. Occasionally it is possible to trace a connection between these and syphilis of the myocardium. In other cases spirochetes are localized in the subepicardial tissues, producing local mononuclear infiltrations and fibroblastic proliferations. Likewise, thickenings of the *endocardium*, valvular and parietal, are very common in syphilitic hearts, *i.e.* in the hearts of syphilitics. The spirochetes may be localized primarily in the endocardium or just beneath it; or the changes may be secondary. The endocardium of the left ventricle below the aortic valves, and the semilunar valves themselves are the especial sites of such changes. Aortic stenosis and insufficiency may be directly produced by such localizations of spirochetes.

Slight degrees of interstitial myocarditis and gummata of small size give rise either to circulatory disturbances or to general symptoms. In the majority of cases the onset is slow and insidious, the symptoms of serious myocarditis developing only when extensive involvement of the heart muscle has occurred. Consequently sudden death from acute cardiac insufficiency is very common, occurring in two-thirds of the cases. In those cases which are observed for some time before death dyspnea, venous stasis, ascites, and general edema gradually developed without the presence of the physical signs of valvular disease. Extensive fibroid change or gummata of large size may lead to aneurysmal dilatation of the heart wall, general hypertrophy, or dilatation accompanied by the gradually developing symptoms of cardiac insufficiency. When gummatous or fibroid changes involve the bundle of His the Adams-Stokes symptom-complex may be present. Marked arrhythmia is very characteristic of cardiac syphilis in general. Rupture of a softened gumma

into the blood stream very frequently leads to thrombosis and embolism. In the reported cases the emboli were found in the vessels of the retina and choroid and in the coronary and pulmonary arteries. Symptoms of angina pectoris are very common, and myocardial and coronary syphilis are the most common causes of angina. A form of syphilitic angina pectoris has been described by some writers who have attributed it to a specific action of the syphilitic poison upon the neuromuscular apparatus of the heart wall or upon the sympathetic nerves. The progress of cardiac syphilis is usually very slow, periods of apparently good health may alternate with extended attacks of cardiac insufficiency. In either period slight accidents may cause sudden death. This may be due to rupture of the heart or to occlusion of the coronary arteries, either through fibroid changes, or through thrombosis or embolism.

The diagnosis of syphilitic disease of the heart rests upon the exclusion of other causal factors and the establishment of the existence of a syphilitic infection, either past or present. In doubtful cases the Wassermann reaction should be taken and the therapeutic test should be employed. A negative reaction cannot be taken as indicating the non-existence of syphilis. The prognosis in undoubted cases of syphilitic myocarditis is very unfavorable if the condition is well advanced. Only in the earliest stages, before much structural change of the heart wall has occurred, is there hope of a cure. The treatment is that pursued in cases of syphilis in general, with special treatment directed to the myocardial condition. The use of salvarsan in well-marked syphilis of the heart is attended with danger. Any intercurrent infection, poison or drug that may cause even slight myocardial changes may upset cardiac sufficiency, and the patient may die suddenly of acute dilatation. The most important line of procedure at the present time is a better, early and prolonged treatment of syphilis. It is very probable that systematic treatment of all cases of syphilis, if continued faithfully for four or five years, would greatly diminish the number of cases of myocardial syphilis.

ALDRED SCOTT WARTHIN.

Heart, Therapeutics of.—See *Heart, Functional Disorders of.*

Heart, Thrombosis of the.—The blood clots found within the heart cavities may be divided into three classes: *postmortem clots*, *antemortem* or *agonal clots*, and *true thrombi*. The postmortem clot is formed after the heart has ceased to beat; it is a soft, dark-red, jelly clot filling up the cavity of the auricle or ventricle and not adherent to the heart wall. It is commonly known as cruor or the "currant-jelly clot." In leukemia with high white-cell count the postmortem clot may be pale or yellowish ("chicken-fat clot"). Such coagula are found usually in the right auricle and ventricle, but may be present in all four of the cavities. When coagulation occurs rapidly after death the clot is uniformly red throughout; but if coagulation is delayed the uppermost portion of the clot may be light-colored or yellowish from the sinking of the red cells. In themselves the postmortem clots are of significance only in so far as the character of the blood and its coagulability are concerned. If coagulation takes place while the ventricles are contracted in rigor mortis the clots will be found in the auricles only, but, if coagulation be delayed until the contraction of the ventricles has passed, the ventricular cavities may again become filled with blood which later coagulates.

The antemortem or agonal clot is a white or mixed clot found in the periphery of the large veins, right and left auricles, and right ventricle, but rarely in the left ventricle. Such clots consist of fibrin with few or many leucocytes, while that part of the clot toward the axial stream may contain red blood cells. They develop during the slowing of the blood stream in cases of slow death, and are formed only in the peripheral stream where there are no red cells. As the current becomes slower red cells are caught in that portion of the clot toward the central stream. As soon as death occurs and the current comes to a standstill, the blood in the central stream coagulates forming a postmortem currant-jelly clot. Combinations of agonal and postmortem clots are thus formed and are distinguished by the presence of a central red clot surrounded by a peripheral layer of white clot. The agonal clot is soft, but much firmer than the currant-jelly clot. It is not attached to the endocardium and is easily removed from between the trabeculæ of the ventricular wall. It is further distinguished from true cardiac thrombi in its moistness, translucency, and greater elasticity. On microscopical examination the agonal clot is found to consist almost entirely of a coarse reticulum of fibrin; on the other hand the fibrin in the postmortem jelly clot is in the form of fine fibrillæ. The significance of the agonal clot is only that of a slowly progressive heart failure; in cases of sudden death without previous impairment of cardiac efficiency the white peripheral clots are either very small or absent, while in cases of slow death in chronic valvular disease, cachexias, etc., they may be very large. Care should be taken to differentiate between these and the true heart thrombi for which they are frequently mistaken.

The true heart thrombi are yellowish, reddish, or reddish-gray or brown, opaque, dry, inelastic, brittle, and in the great majority of cases more or less adherent to the endocardium. The conditions under which they are formed are practically the same as those of thrombosis of the blood-vessels, the chief factors being lesions of the endocardium (thromboendocarditis), disturbances of the circulation, and changes in the chemical composition of the blood. Of these the endocardial changes are by far the most important. The exciting agents are most frequently streptococci and staphylococci, after these the pneumococcus, influenza-bacillus, gonococcus and other bacteria, and more rarely the tubercle-bacillus. The bacteria may produce lesions locally in the endocardium by their presence or through the action of their toxins. Syphilis is indirectly a very common cause of cardiac thrombosis in that it produces anemic infarction of the myocardium as a result of changes in the coronary vessels. On the damaged endocardium over the myocardial necrosis a thrombus is formed. Changes in the character of the blood (anemia, cachexia, intoxications, etc.) and disturbances of the circulation are also factors in the production of cardiac thrombi. At the point of lesion blood plates are first deposited, followed by the processes of conglutination and coagulation as in the formation of thrombi in the vessels. The resulting thrombus is usually a mixed clot, very frequently laminated. When formed in the peripheral stream with rapid circulation it may be entirely white; if the current is very much slowed it may be red throughout. In old red thrombi the diffusion of the hemoglobin from the red cells may give a washed-out reddish or brown color. The latter color is also the result of the formation of blood pigment from the disintegration of the red cells. The surface of the thrombus is not infrequently ribbed; this appearance has been explained as being due to wave-like movements in the blood, the process being analogous to the formation of wave marks on sandy bottoms. The general external appearances of cardiac thrombi are dependent upon the manner of formation, rapidly of development and the local conditions of the circulation. The size and shape of cardiac thrombi show great variation. They may be so small as to be hidden between the muscle columns, or so large as completely to fill one of the heart cavities. They may appear as small globular masses projecting from between the muscle

trabeculæ (globular vegetations); or as flat, circumscribed masses firmly attached to the heart wall. On the valves they may form beadlike excrescences or vegetations. Not infrequently the thrombus is attached to the endocardium by a pedicle (heart polyp); as the result of the tearing of such attachment free globular thrombi may be formed (ball thrombi). In rare cases the thrombus may be spread over the endocardium like a false membrane.

The thrombus when cut into may be found to be made up of dry and brittle laminations, in some instances the central portion of the thrombus is under slight pressure easily crumbled to dust. In other cases the central portion may be cystic, the cavity filled with a thick reddish-brown or pus-like substance. Such secondary degenerations are of frequent occurrence. The most common is a simple softening or liquefaction (autolysis); when many leucocytes are present a grayish pus-like fluid may be formed; if the degenerating portion is made up of red cells alone a grumous reddish-brown fluid results. Calcification of the thrombus may also take place, resulting in the formation of a cardiolith. As a more favorable sequela of cardiac thrombosis organization of the thrombus may occur, the latter becoming ultimately converted into a nodular or diffuse fibrous thickening of the endocardium. In some cases both the degenerating and the organized thrombi have been mistaken for cardiac neoplasms, cysts, and fibroma respectively. It is also not improbable that some of the growths on the endocardial surface described as myxoma were recently organized thrombi.

The microscopical examination shows the cardiac thrombi to be composed of fibrin, disintegrated blood cells, blood pigment, masses of calcification, etc. In case of simple softening of the central portion the cavity thus formed contains granular débris, blood pigment, etc. In recent thrombi the leucocytes present may still show traces of their nuclei. If organization has begun fibroblasts and new capillaries may be seen extending from the endocardium into the thrombus.

Thrombi are more frequently found in the right side of the heart than in the left and in the auricles rather than in the ventricles. In the auricles the appendix, and in the ventricles the neighborhood of the apex are the favorite seats of location. Predilected sites are the remains of valves, the valvula Thebesii in the right auricle, and the valvula foraminis ovalis in the left. The pedunculated thrombi (cardiac polyps) are of frequent occurrence in the right ventricle, while the free ball thrombi, in the majority of recorded cases, were found in the dilated left auricle in cases of mitral stenosis. Cardiac thrombi may be single or multiple, and may be found at any age. According to their location in the heart they are also designated as parietal and valvular.

Etiology.—The changes in the endocardium leading to thrombosis are either inflammatory, or degenerative, or necrotic in nature. These lesions may be the result of the local action of pathogenic bacteria or due to general intoxications, disturbances of nutrition, changes in the blood, etc. The pus-forming organisms, gonococcus, and tubercle bacillus have been found in cardiac thrombi under such conditions as to make it very probable that they were the exciting factors of the thrombosis. The valvular vegetations are in the majority of cases due to bacteria. In the acute infections fatty degeneration of the endocardial endothelium not infrequently leads to thrombosis. Local changes in the myocardium, such as anemic infarction, myocarditis, etc., are usually associated with the formation of thrombi on the overlying endocardium. Aneurysmal dilatations of the cardiac wall are very likely to be partly or wholly filled by a thrombus. Thrombosis of the left ventricle is practically always the result of changes in the heart wall due to syphilis. In many chronic diseases in which there are general disturbances of nutrition, systemic intoxication, etc., as in chronic nephritis, pulmonary tuberculosis, chronic valvular disease, etc., heart thrombi are frequently found. In pulmonary tuberculosis they are of such frequent occurrence as to give rise to the suspicion that in many cases they may be due to the local action of tubercle bacilli which have lodged upon the endocardium. Cardiac thrombosis often occurs in cases of general cachexia (marasmic thrombi). In severe superficial burns of the skin the changes produced in the blood may lead to the formation of thrombi, both in the right side of the heart and in the pulmonary arteries. Small emboli coming from venous thrombi and lodging upon the valves or between the muscle trabeculæ of the right ventricle may give rise to secondary or induced thrombi. Sclerotic changes in the valves or mural endocardium followed by atheromatous degeneration or calcification may also become the seat of thrombosis. Dilatation of the heart and slowing of the blood stream are favoring factors in all of the conditions named above, but are probably not in themselves sufficient to cause thrombosis; the changes in the endocardium must be regarded as of prime importance.

Symptoms.—Thrombi of large size may exist indefinitely without serious impairment of cardiac efficiency. In the majority of cases the symptoms produced cannot be differentiated from cardiac insufficiency due to other causes. The physical signs are those of dilatation; in case of the blocking of a valvular orifice by the thrombus the heart's action is usually too weak to produce audible murmurs. The valvular vegetations may give rise to symptoms of stenosis or insufficiency. In the case of the ball thrombi so frequently formed in the left auricle in mitral stenosis sudden death or the most serious disturbances of circulation may be caused by the complete or partial blocking of the mitral orifice. The occurrence of embolism, either of the pulmonary or of the systemic arteries, is the symptom of greatest value in the diagnosis of cardiac thrombosis and the symptoms would resemble those of thromboendocarditis verrucosa. Embolic abscesses may be produced throughout the body in the case of emboli arising from thrombi caused by pyogenic bacteria. In the case of a patent foramen ovale paradoxical embolism from thrombi in the right side of the heart may occur. In general it may be said that the diagnosis of cardiac thrombosis is usually impossible, having been made in but few cases. Aside from the occurrence of embolism the irregularity of the symptoms and physical signs may excite suspicion of a movable body within the heart.

Prognosis.—This is bad, not only because of the interference of the heart's action and the danger of embolism, but also because of the conditions which have led to the thrombosis. The treatment is directed chiefly to the latter and to the support of the heart.

Aldred Scott Warthin.

Heart, Tuberculosis of the.—Tuberculosis of the myocardium is very rare. The first recorded case is that of Townsend in 1832. In 1894 Valentin collected thirty-six cases from the literature, and estimated that the condition occurred but once in 1,000 tuberculous bodies. Hand, in 1898, collected forty-two cases, and in 1899 Thiry was able to gather sixty-three cases from the literature up to that year. With the exception of a few cases the condition was secondary to tuberculous disease elsewhere in the body. Demme and Knopf have reported cases thought to be primary. The majority of the cases occurred before the fifteenth year, several in infants. The ventricles are more often affected, the wall of the right auricle next in frequency. In the majority of cases the lesions are

characterized by the scarcity of tubercle bacilli found in them.

The infection of the myocardium occurs either by direct extension from the pericardium or endocardium, or by hematogenous or lymphogenous metastasis. According to some writers a retrograde lymphogenous metastasis from the bronchial lymph glands forms the most common means of infection. This is denied by others, inasmuch as the lack of collateral anastomosis of the cardiac lymph vessels does not favor retrograde metastasis. In the miliary cases the avenue of infection is usually through the veins.

The disease may manifest itself in several forms: (1) Scattered miliary nodules through the muscle; (2) larger caseous nodules varying in size from a pea to a hen's egg, usually multiple, but occasionally single; (3) diffuse tuberculous myocarditis in the form of a fibroid change with scattered caseous nodules of small size; (4) fibroid myocarditis with small non-caseating tubercles. The third and fourth forms are very rare; and are with difficulty distinguished from syphilitic processes, as the bacilli are found in such scanty numbers as to be very difficult of demonstration. The miliary tubercles are usually most numerous just beneath the epicardium, occasionally beneath the endocardium. They rarely extend far into the muscle. The large caseous tubercles represent a more chronic infection; they may be encapsulated or show extensive signs of healing. In these cases the pericardium is almost always involved, the endocardium only rarely when the lesion is in the ventricles. In the case of a tubercle of large size developing in the auricular wall both peri- and endocardium are soon involved. Perforation into the auricular cavity may take place and give rise to a general miliary tuberculosis. In a case reported by Püschmann there was an acute miliary tuberculosis which seemed to have taken its origin from a thrombus containing numerous tubercle bacilli which was attached to a caseating tubercle in the auricular wall.

With slowly developing tubercles there is always associated an interstitial myocarditis. In the case of the large caseous tubercle this process is confined to its immediate vicinity. This form of interstitial myocarditis is much less important than the diffuse form associated with scattered tubercles of slow growth and showing little tendency to caseate. In spite of the weakening of the cardiac wall through replacement of the muscle by connective tissue and through caseation of the tubercle, a rupture or aneurysm of the wall is not likely to occur in these cases because of the diminished blood pressure. In none of the recorded cases of myocardial tuberculosis has this event been observed. Further, there is usually extensive fatty degeneration of the heart muscle in the neighborhood of the tuberculous process, and this diminishes to a still greater degree the efficiency of the heart's action. Calcification or encapsulation of the caseous tubercles may occur here as elsewhere. Complete healing may result, the tubercle being wholly replaced by connective tissue.

Within very recent years the presence of tubercle bacilli in parietal thrombi and endocardial vegetations has been many times demonstrated, and it is very probable that tuberculous endocarditis is of much more frequent occurrence than is usually supposed. The great frequency of cardiac thrombi in pulmonary tuberculosis suggests the possibility of their formation by the lodgment of bacilli upon the endocardium. The appearances are those of an ordinary verrucose endocarditis. Microscopically the tuberculous thrombi contain granulation tissue with typical giant cells, epithelioid nodules that caseate and contain tubercle bacilli in large or small numbers (*thromboendocarditis tuberculosa s. caseosa*). In the great majority of cases, however, the cardiac vegetations found in tuberculosis represent a thromboendocarditis simplex. They may be the result of secondary infection or due to the action of toxins. Tubercle bacilli may occur in these secondarily. Secondary involvement of the myocardium may follow the development of endocardial tubercles.

Tuberculosis of the myocardium presents no characteristic symptom complex, and in the great majority of cases cannot be diagnosed. The symptoms depending directly upon the condition would be those of a myocarditis. Involvement of the pericardium may give rise to such definite signs and symptoms as to permit of the diagnosis being made. In case of pericardial effusion a bacteriological examination of fluid obtained by puncture could be made. The termination of the cases is by death, due usually to the general tuberculosis rather than to the condition of the heart. Rarely solitary tubercles of small size and slow growth may heal. For the great majority of the cases there is no treatment beyond that of a purely symptomatic nature. Aldred Scott Warthin.

Heart, Valvular Lesions of the.—General Etiology.—The great majority of cases of chronic valvular lesions originate in acute or chronic endocarditis. A single attack of acute rheumatism may leave the valves in a seriously damaged condition, but more frequently contraction and thickening of the valvular apparatus continue after the acute stage has passed off, and the leaflets gradually become deformed and defective in function. Recurring attacks of endocarditis are liable to occur in valves once damaged by this cause, and slight defects may thus terminate in serious and irreparable injury.

Valvular deformity may also originate in a chronic sclerotic process, comparable to the changes which take place in sclerosis of the vessels. Although this chronic process may originate from rheumatic influences, yet there are a number of causes which, when taken collectively, exert a more frequent influence.

That high arterial pressure is capable of producing valvular lesions is shown very clearly by the experiments of Roy and Adami. These observers narrowed the aorta of the dog by clamping and thus induced a fringe of swollen tissue at the free edge of the valve, due to infiltration of cells and edema.

Clinically it is well recognized that long-continued high arterial pressure may result in sclerosis and thickening of the valves. More particularly is this noticed in the aortic segments which have to bear the brunt of increased strain in the arterial system; the mitral cusps often suffer as well, and thickening of their free borders is very frequent in cardiac hypertrophy, a condition in which they are subjected to increased strain.

The proportion of cases originating in acute and in chronic endocarditis, has been variously estimated. It is more common to trace an origin in acute endocarditis, resulting from rheumatism or other infectious processes, in the mitral than in the aortic segments. In aortic lesions the process is frequently chronic from the outset.

Guttmann regards three-fourths of all valvular cases as beginning in a chronic fashion, and Worobjew's (*Deut. Arch. f. klin. Med.*, 69, 466) analysis of 180 cases also confirms this view. Most writers have, however, regarded the rheumatic cases as the most frequent; Schott attributes 54 per cent., and Gibson 63 per cent. of cases to a rheumatic origin.

Aortic Incompetence.—*Etiology.*—Although occurring at all ages and in both sexes, it is far more commonly met in males about the middle period of life. Under the age of twenty-five most cases are due to a rheumatic origin, and in these it is usual to find the mitral valve also affected. A belief in the influence of syphilis as the most frequent etiological factor in aortic incompetence is gradually gaining ground. In a recent important study by Longcope (*Arch. Internal Med.*,

Jan., 1913, seventy-five per cent. of cases of aortic insufficiency in adults are attributed to syphilis. The morbid process begins in the root of the aorta, being often associated with dilatation and eventually with involvement of the aortic segments. Although there is reason to believe that the lesion originates in the secondary stage, yet the process is usually latent for a long period and is only recognized by clinical symptoms and signs many years after the original infection. All conditions leading to continued or even intermittent high pressure tend to the development of fibroid thickening of the cusps, inducing retraction and incompetence. Incompetence is consequently often seen in arteriosclerosis, chronic Bright's disease, gout, plumbism, and chronic alcoholism. Those engaged in laborious physical work constitute the greater number of cases. It is consequently frequent in laborers, and is occasionally seen in athletes. Old soldiers often suffer from the disease, owing partly to laborious physical exertion, partly to chronic alcoholism, and particularly to specific infection. Tabetics are not infrequently attacked by aortic insufficiency, a fact attributed by Gowers to a common origin in syphilis. Owing to the frequent involvement of the coronary vessels in the sclerotic processes at the root of the aorta, the arterial cases are usually more serious than those due to stationary rheumatic endocarditis.

Morbid Anatomy.—In the great majority of cases aortic incompetence is due to a chronic sclerotic process in the valves. Their free edges become thickened and retracted, and the cusps fail to support a column of water when poured into the aorta. Their edges frequently adhere to each other, causing more or less obstruction. Patches of atheroma are often present on the valves, and in old-standing cases there may be an abundant deposit of lime salts, giving a hard bony feel to the margins of the orifice. When extreme adhesions and stenosis are present, a transverse bar is sometimes seen running from the united cusps to the wall of the aorta, and represents the margins of the original segments. The mitral valve is frequently involved in the sclerotic process, in the rheumatic cases. The root of the aorta often presents atheromatous and calcareous plates and in many instances it is dilated. Characteristic syphilitic lesions involving the root and ascending portion of the aorta are frequently found, and the thickened and puckered cusps form a part of the morbid process. In this affection the aorta often presents a diffuse dilatation and the mouths of one or other coronary arteries may be narrowed or almost obliterated by the syphilitic plaques. Fresh endocarditis is frequently added on to older lesions, and it is not uncommon to find a row of warty granulations along the edge of the valve. Vegetations are found in the course of acute rheumatism and in malignant endocarditis. They may interfere mechanically with the closure of the valves, or in the latter instance cause incompetence from rupture of one of the segments.

Dilatation of the root of the aorta, the result of atheromatous or syphilitic changes, is a rare cause of aortic insufficiency. A series of cases has been recorded by Pitt (Trans. Path. Soc., 1898) in which incompetence was induced in this way, without marked changes in the valve. In aneurysm it is very common to find aortic regurgitation, but in such cases it is usually due to a coexisting sclerotic change in the valve. With advancing age the aortic orifice becomes wider, but the comparative rarity of aortic incompetence in old people would seem to indicate that the dilatation is insufficient to allow of regurgitation.

Osler has pointed out the frequency with which sclerosis and insufficiency occur in those cases of malformation in which two, instead of three cusps exist.

Rupture of the aortic cusps occurring spontaneously, or more commonly from violent efforts, or as the result of severe direct injury to the chest has been recorded in a number of instances, and is a rare cause of aortic incompetence. Barié has shown that rupture may be produced experimentally, and that the aortic cusps suffer more readily than other valves. Although perfectly healthy valves may suffer in this way, yet in most instances there is evidence of previous sclerotic change. The average age at which rupture occurs is thirty-nine, a period of life at which degenerative changes are common, and is suggestive of previous disease.

Important secondary changes take place in the cardiac chambers as the result of aortic incompetence. The left ventricle is obliged to accommodate not only the usual amount of blood from the auricle, but also that which regurgitates during diastole of the ventricle. The consequence is that this chamber becomes dilated to an extent corresponding with the volume of blood passing from the aorta, and the degree to which dilatation takes place is thus an index to the extent of regurgitation. In the severer types of the disease dilatation is extreme, and the heart reaches a size seldom attained under other circumstances, the *cor bovinum.* Although dilatation is primary and the cavity remains greatly enlarged, some hypertrophy of the ventricular wall also results, and thus balances or compensates for the diseased valve. Owing to the difficulty it experiences in propelling blood into a ventricle already distended, the auricle in turn dilates and hypertrophies, and eventually the right heart becomes involved as in mitral disease.

Symptoms.—This lesion is most frequently discovered during the routine examination of patients in apparent health, or in the subjects of other maladies. Compensation is often well maintained for years, and during this period there are few or no subjective symptoms, and indeed there is usually much less discomfort than in mitral lesions. Dizziness, palpitation, and precordial pain are sometimes noticed, and dyspnea on exertion is often an early symptom of failing compensation. The facies presents in many instances a pale and anxious aspect, contrasting with the cyanosis of mitral affections.

An exception to the insidious onset is seen in cases of ruptured valve. Here the abrupt onset with severe precordial pain and dyspnea, the development of a diastolic murmur, sometimes so loud as to be perceptible to the patient himself, the occurrence immediately or shortly after some unusual strain or external violence to the chest, form a clinical picture which is very striking. The severer cases may terminate fatally in a few weeks, but for the most part they survive for a longer period. Two of Barié's cases lived for eleven and thirteen years respectively.

Failing compensation is marked by dyspnea, palpitation, and swelling of the feet. Dyspnea, as in other forms of cardiac disease, comes on from exertion, especially in mounting a hill or climbing a stair. As the malady advances there are often attacks of paroxysmal dyspnea, coming on especially at night, and known as cardiac asthma. Loss of sleep and a moderate loss of flesh give the patient a worn and anxious aspect. Edema, if present, is usually moderate in extent, except in advanced cases in which there is secondary mitral incompetence, when it may attain a high grade.

Pain is more commonly present in aortic than in other valvular lesions. It varies much in intensity, from a sense of weight and uneasiness to agonising attacks of angina. The pain is frequently induced by exertion, and is felt over the precordium and in the same sites as angina, with which some of the attacks are identical.

In advanced stages of the disease orthopnea and Cheyne-Stokes breathing, either with or without general anasarca and the visceral congestion of mitral lesions, may be present.

Mental disturbance develops more commonly in aortic than in other valvular affections, and shows

itself in restlessness and change of temper. In some instances delusions are prominent and the patient may require restraint.

The symptoms in many instances are dominated by those of arteriosclerosis or chronic renal disease, in which the incompetent valve is merely an incident. Sudden death is an accident which may ensue even in apparent health. Such an occurrence is more liable to happen when there is disease of the coronary vessels. Death occasionally comes rather unexpectedly after the symptoms of ruptured compensation have lasted for some time, but the more common termination is by gradual failure, dropsy, and asystole.

Physical Signs.—Visible pulsation in the arteries often suggests the existence of aortic incompetence. Throbbing of the carotids, visible pulsation in the radial and temporal arteries, and, in severe cases, even in the digital branches of the hands and feet are distinctly seen. Pulsation of the palate and uvula has been observed, and the pulse may be counted in the retinal arteries with the ophthalmoscope. Capillary pulsation is seen in the finger nails, and is also readily observed in the lips when a glass slide is pressed on them. The pulse has certain characters which at once reveal the nature of the affection to the practised finger. The wave is large, it strikes the finger suddenly and as rapidly recedes, these characters being more marked when the arm is raised. Since the appearance of Corrigan's paper, this pulse has gone by his name, and is also known as the water-hammer or collapsing pulse. It is regular in volume and rhythm except in the later stages, when slight irregularity may develop. The arteries are frequently thickened and this feature is seen even in young people suffering from the rheumatic form of the disease.

Examination of the heart shows the presence of very distinctive signs, the more important being the increased size of the organ and the diastolic murmur at the base. These signs, taken in conjunction with the arterial phenomena, render the affection one of the easiest of cardiac lesions to recognize.

Inspection often shows a slight degree of fulness in the cardiac region, particularly in children and young adults, in whom the chest wall is more elastic. Visible pulsation is seen below and outside the normal apex site, and retraction may be seen in the third and fourth spaces due to atmospheric pressure during systole.

On palpation the cardiac impulse is forcible and heaving, and the apex is felt in the nipple line or as far out as the mid-axilla, in the fifth, sixth, or even the seventh space. The increased area of the heart is also shown by percussion, the dulness extending down and to the left side.

The most characteristic sign is found on auscultation in a diastolic murmur, due to the reflux of blood to the ventricle. It is usually a soft prolonged souffle, beginning with the second sound, and occupying the greater part of the diastolic interval; it is sometimes shorter or its character may be harsh. Although sometimes having its site of maximum intensity at the aortic cartilage, it is usually best heard about the pulmonary region. It is transmitted down the sternum, especially to its left side, and is occasionally heard only at the lower sternal region. It is frequently transmitted to the apex, and when loud is heard all over the front and back of the chest. The diastolic murmur in question is one of the most persistent of cardiac murmurs. It occasionally disappears during periods of asystole, to reappear with increasing cardiac power. Instances have been reported in which the murmur disappeared from closure of the orifice by a vegetation, and Musser has recorded a remarkable case in which the leak ceased owing to wearing down of the thickened corpora Arantii. A systolic murmur commonly precedes the diastolic sound, and with it gives the well-known to-and-fro murmur.

The second sound is often dull and indistinct and may be entirely lost. When absent it indicates serious deformity of the valve segments and is usually a sign of extensive regurgitation. The sound should be listened for in the arteries of the neck, as it may be present, but obscured by murmurs at the base of the heart.

The gradual development of aortic incompetence may sometimes be traced from an accentuated second sound in arterial sclerosis to the diastolic murmur of the incompetent valves.

A presystolic murmur at the apex was first described by Flint in cases of aortic incompetence, and commonly goes by his name. It exactly resembles the rumbling murmur heard in many cases of mitral stenosis. Thayer in a recent study of this murmur states that it was present in sixty per cent. of his cases, and that thrill, snapping first sound, and the tapping impulse of mitral stenosis were also occasionally noticed. The pulse characters form the best guide in distinguishing the two conditions, but when they are combined it is often difficult or impossible to state whether the murmur is associated with mitral stenosis or is due to aortic incompetence.

The temperature in cardiac disease is usually subnormal. Elevation of temperature is sometimes the first evidence of a fresh endocarditis. It may, however, signify some rheumatic or other inflammatory complication. In the advanced stage of cardiac disease it is most often due to a bronchopneumonia, and is frequently seen a few days preceding death.

Diagnosis.—The physical signs of a well-marked case of aortic incompetence are unmistakable. The diastolic murmur is a very constant feature, only seldom disappearing in advanced cases with asystole. Temporary diastolic murmurs are occasionally heard in arteriosclerosis, the valve probably yielding to the increased blood pressure. Allbutt regards such cases as the early stage of the affection. A diastolic murmur is sometimes heard in mitral stenosis at the pulmonary area, and represents a temporary incompetence of the pulmonary leaflets from increased pressure in this vessel. Such a murmur is distinguished by the small pulse of mitral disease, instead of the large collapsing pulse of aortic incompetence.

The degree of regurgitation is estimated by the size of the ventricle and the character of the pulse. Disappearance of the second sound at the base and in the arteries of the neck also indicates free regurgitation.

It is of great importance from a therapeutic standpoint to distinguish the syphilitic cases. The Wassermann test is invaluable for this purpose, being often positive when no other evidence of the disease exists. A history or evidence of syphilis or the presence of the Argyll-Robertson pupil may however give the clue to the underlying condition.

Aortic Stenosis.—*Etiology.*—Although occurring at all ages, and sometimes as the result of changes in early life, aortic stenosis is most common in old men with calcareous arteries.

In high degrees of the affection the valves are thickened and calcareous and the orifice may become so narrowed as hardly to admit a probe. In rare cases the obstruction is subvalvular and the result of an attack of fetal endocarditis. Stenosis, apart from the slighter grades of the affection, and unassociated with aortic incompetence, is a rather rare condition.

The symptoms are similar to those found in aortic regurgitation, and depend rather on associated conditions, such as generalized arteriosclerosis, sclerosis of the root of the aorta, disease of the coronary vessels, and myocarditis, than on the aortic lesion itself.

The onset of the affection is insidious, and there is a long period of latency. Uneasiness or pain in the cardiac region, sometimes assuming the characters of true angina, cardiac oppression, palpitation and dizziness, dyspnea, and syncopal or even epileptic

attacks, may be among the earlier symptoms. In the later stages dilatation of the left ventricle takes place and relative mitral insufficiency ensues. Dropsy and the usual evidence of venous stasis set in, and the clinical picture assumes the type seen in the more advanced stages of mitral disease.

The diagnosis rests on the physical signs. The peripheral arteries are usually thickened and calcareous, while the characters of the pulse afford valuable evidence of the nature of the lesion. It is small, often of high tension, the upstroke is slow and gradual, the wave is well sustained and it falls away slowly. These features are well shown in a sphygmographic tracing; the upstroke is oblique and is sometimes interrupted by an anacrotic notch, like the dicrotic notch in the downstroke. This notch has been regarded as a double effort on the part of the ventricle during systole, but it occurs in other conditions and has no special diagnostic significance; the apex of the curve is rounded and the downstroke gradual. The pulse rate is often infrequent, falling to 60 or below. (*Vide* Clin. Soc. Trans., 1897.)

Evidence of hypertrophy of the ventricle is present, but the enlargement does not reach the degree seen in aortic incompetence. Inspection and palpation reveal an apex beat below and outside the normal site, with a strong heaving character. Emphysema of the lungs, however, is frequently present and prevents the apex site from being determined, rendering it weak and indistinct. Under these circumstances cardiac dulness is often lessened. A systolic thrill about the aortic cartilage is commonly present; it is often well marked and of great intensity, and is sometimes transmitted to the vessels of the neck, or felt in the episternal notch. With failing cardiac power the thrill may lessen or disappear. On auscultation a rough harsh murmur is heard in the aortic region, occasionally having a musical character. It is prolonged through the whole of systole, often completely obscuring both sounds of the heart, the second being lost from the rigid character of the valves. It is best heard about the aortic cartilage and transmitted to the vessels at the root of the neck. It is heard over the cardiac area with diminishing intensity toward the apex, and in many cases it is so loud that it is heard all over the chest and even at a short distance from the patient. In the terminal stages of the malady, with failing cardiac action, the murmur may lose something of its intensity and roughness.

Diagnosis.—A common error is to regard all aortic systolic murmurs as due to stenosis. Murmurs in this region are most frequently due to atheroma of the root of the aorta, to slight sclerotic changes in the valves, or they are of a functional character. They are then often less loud and rough than in cases of stenosis. Coarse atheromatous changes in the aorta may, however, cause both a rough murmur and a thrill, and it may prove difficult or impossible to distinguish such a condition from true stenosis. An accentuated second sound is common in atheromatous states, and is not likely to be present in stenosis owing to the rigid state of the valves.

The peculiar characters of the pulse, the marked characters of the murmur, and the presence of thrill form a combination of signs which are highly characteristic and, when distinct, are unmistakable.

Mitral Incompetence.—This may result from acute or chronic endocarditis, from rupture of the chordæ tendineæ, or from dilatation of the ventricle preventing the apposition of the valve segments.

In young people a large proportion of cases originate in acute endocarditis; hence the frequency with which a history of acute rheumatism occurs in the clinical history. It is by no means infrequent to obtain no history of rheumatic conditions, even in children and young people, while in older individuals a chronic sclerotic process is often the primary change.

The mitral valve is much more liable to rheumatic inflammation than the aortic, and in fact the latter valve seldom suffers from this cause without involvement of the former.

In malignant endocarditis, rapid ulceration or necrosis of the valves, or rupture of the chordæ, is occasionally responsible for serious destruction of the valve. Rupture of the chordæ also occurs, apart from acute endocarditis, as a result of strain or external violence, although such cases are very unusual. Cardiac dilatation, resulting from strain or from myocardial changes, often produces relative mitral incompetence, even with perfectly healthy valves. This condition is frequent as a temporary manifestation in the acute dilatation of infectious disease and in anemia. In aortic lesions and in chronic dilatation or myocarditis, incompetence occurs owing to this mechanism.

Morbid Anatomy.—The changes in old-standing cases consist in thickening and rigidity of the valvular segments. In cases due to endocarditis, there is almost invariably some degree of narrowing. The orifice is naturally wider than normal when relative incompetence is present.

Secondary changes of a compensatory character take place in the various cardiac cavities. The left auricle dilates to accommodate the extra current of blood passing through the leaking valve, and also hypertrophies to cope with the increased work thrown upon it. The ventricle undergoes similar changes, being stimulated by the increased flow from the left auricle. The circulation in the pulmonary circuit is impeded by the overfilled auricle, and in consequence the right ventricle and ultimately the right auricle dilate and hypertrophy.

The tricuspid orifice, owing to dilatation, may become incompetent, a feature which accounts for certain clinical phenomena in the advanced stage of the affection. Sclerotic changes occasionally occur both in the trunk and in the smaller branches of the pulmonary artery, owing to the increased blood pressure.

A deposit of fibrin among the musculi pectinati or chordæ tendineæ is seen in the dilated cardiac chambers, and forms the usual source of emboli.

Venous stasis in the various organs is frequent in mitral lesions. The lungs are affected earliest, and undergo the change known as brown induration. The capillaries are overfilled and consequently thrown into loops, while blood pigment passes to the alveolar walls, and a slight increase of interstitial tissue, the result of chronic congestion, takes place. The epithelial lining in the alveoli is somewhat swollen, and contains specks of pigment.

Hemorrhagic infarcts are common in the advanced stages. They are often attended by hemoptysis and a localized pleuritis. Edema of the lungs and hydrothorax are frequent as manifestations of part of a general dropsy, and a terminal bronchopneumonia is a common cause of death.

The liver shows dilatation of the radicles of the hepatic veins in the centers of the lobules, with an exudation of pigment in the surrounding cells, while the periphery of the lobule undergoes fatty changes owing to deficient oxygenation. To the naked eye the cut surface presents a mottled appearance, the dark-colored centers contrasting with the pale peripheral portions of the lobules, and giving the organ the name of the nutmeg liver. When congested it is enlarged and extends below the costal border, and in the later stages fibroid changes may supervene, the organ becoming indurated and uneven on the surface, a condition known as cardiac cirrhosis.

Somewhat similar changes take place in the kidneys; these organs are enlarged and congested in the earlier stages, and eventually may become cirrhotic and contracted.

Edema and congestion of the gastrointestinal tract,

and subcutaneous edema with effusion into the serous sacs, are also present in the advanced stages of the affection.

Symptoms.—These vary greatly according to the character and stage of the disease.

In acute endocarditis the development of a mitral incompetence is revealed only by the physical signs; dropsy and dyspnea are only exceptionally present even in the graver forms of endocarditis, and the clinical picture is that of the primary infectious process. In chronic cases compensation may be maintained for a long period, even when the serious nature of the lesion is shown by a greatly enlarged heart and an apex murmur. Although some individuals pass through a long life with little or no discomfort, it is more usual to find some dyspnea on exertion. The facial appearance is often suggestive. The lips and cheeks may be of a deeper tinge than usual, the veins of the neck are distended, and there is stellate enlargement of the veinules of the cheeks, and occasionally clubbing of the finger nails. Attacks of palpitation are often induced by exertion, but they may also result from flatulence. A dry hacking cough or recurring attacks of bronchitis are frequently found.

Among the graver symptoms are a weak, irregular pulse, dropsy, and increasing dyspnea. Breathlessness is brought on by even slight exertion, ultimately becoming constant even at rest. The respirations are deep and labored, accompanied by contractions of the extraordinary muscles of respiration, and the patient rests propped up by pillows, or leaning forward in an arm-chair. Attacks of Cheyne-Stokes breathing are often seen, or again paroxysms of dyspnea often occurring at night and interfering with rest.

Accompanying the dyspnea is edema, which begins about the feet and ankles, noticed first after being up, and disappearing with a night's rest. Unless checked by suitable treatment it gradually increases, and extends to the thighs, scrotum, and serous sacs. The face remains free, but the upper extremities sometimes share in the progressing edema. The edema is firm and hard, and is accompanied by coldness and cyanosis of the extremities, and lividity of the face. When the abdomen becomes distended with fluid it still further embarrasses the breathing.

Hydrothorax is usually bilateral, but in some instances occurs chiefly on one side. In some cases the dropsical effusion affects principally the serous sacs, particularly the peritoneum, and requires periodic removal. It sometimes collects with extraordinary rapidity, after a period of absence.

Sleeplessness, starting from sleep, and bad dreams occasionally occur, even apart from the severer symptoms of failure of compensation.

Of the various organs the liver is enlarged and somewhat tender, frequently reaching as low as the umbilicus. A slight tinge of jaundice is very common, and bile may be detected in the urine. The secretion of urine is greatly diminished, sometimes falling to three or four ounces, or even being suppressed. It is of high specific gravity, it deposits a sediment of urates, and shows albumin in small or moderate quantities, and often granular and hyaline casts. With the disappearance of dropsy diuresis sets in, and the urine may run up to two or three times its normal quantity, with disappearance of albumin and later of casts. Gastric symptoms such as flatulence and sometimes nausea and vomiting, are not uncommon.

With appropriate treatment dyspnea and edema may disappear, and the patient be restored to comparative health. Sooner or later, however, the same symptoms recur, particularly in individuals who are unable to obtain the necessary rest. It is frequent to note several such attacks before the fatal issue.

Eventually a period is reached when the heart, in consequence either of extreme dilatation or of myocardial degeneration, fails to respond to treatment. The terminal illness is frequently very prolonged, and for several months the unfortunate individual struggles with dyspnea and dropsy, and eventually succumbs to exhaustion.

Physical Signs.—The most characteristic sign is a systolic murmur, heard best at the apex. It is variable in character, being sometimes loud and bellows-like, sometimes having a musical character, or again being extremely soft and distant. Faint systolic murmurs at the apex also occur with slight defects in the valve, and in conditions of temporary dilatation, while a loud bellows or a musical murmur usually indicate more definite changes in the valve. The murmur of incompetence may, if faint, be localized at the apex, but it is usually transmitted to the axilla, or heard in the back at or above the angle of the scapula; it is often heard up to the pulmonary cartilage and near to the ensiform, and it may even have its site of maximum intensity at the pulmonary area. The first sound is often obscured or replaced by the murmur, while the second sound is accentuated at the pulmonary area. With failing power of the right ventricle accentuation disappears, and is thus of unfavorable omen.

A thrill is of the rarest occurrence in mitral incompetence. When there is any considerable degree of regurgitation there is enlargement of the left ventricle. The impulse is strong and heaving, and lies in a line with, or outside the nipple; a well-marked epigastric pulsation is often present owing to hypertrophy of the right ventricle. As dilatation or weakness supervenes, the impulse becomes weak and diffuse. Fulness and distention are sometimes seen, particularly in the yielding chest walls of children. Percussion shows an increase in dulness to the left and often to the right, extending beyond the right sternal border or even to the parasternal line. Upward, dulness often begins a space higher than normal.

Diagnosis.—It is not uncommon to find a systolic murmur at the apex in the absence of any other sign of cardiac disease. Its chief importance is the mental disquietude it may cause in nervous patients, and the unfavorable light in which it is usually regarded by life insurance companies. Such murmurs are sometimes evidence of slight valvular damage, but in the absence of symptoms and of other signs of disease, such as enlargement and pulmonary accentuation, they may be disregarded. A murmur heard toward the end of inspiration, and attributed to the entry of air into the pulmonary vesicles during systole, is not uncommon, and is known as the cardiorespiratory murmur. It has usually no cardiac significance. It is not always possible to distinguish regurgitation due to a valvular lesion from that of muscular dilatation. In elderly individuals, in Bright's disease or arterial sclerosis, or in anemia, the latter condition may be suspected. A history of rheumatism or chorea, on the other hand, suggests endocarditis. In some instances, as in anemia and in acute dilatation from strain or infectious fevers, any doubt is often cleared up by the gradual disappearance of the morbid signs.

Mitral Stenosis.—Narrowing of the mitral valve is for the most part a disease of the first half of adult life, often starting from an acute endocarditis in childhood. It is much more common in females, owing doubtless to the greater frequency of rheumatism in young girls than in males of the same age. Although the lesion is often regarded as of purely rheumatic origin, it is remarkable how often a history of acute rheumatism is absent. In children, however, rheumatism, as pointed out by Cheadle, is frequently an ill-marked condition, the articular manifestations being slight, or replaced by such symptoms as tonsillitis, growing pains, or erythema, and yet in these apparently slight cases severe forms of endocarditis may develop.

Cases of mitral stenosis are occasionally found in a first attack of acute rheumatism, a fact strongly suggestive of an old-standing latent rheumatic influence. An absence of a history of acute rheumatism is therefore no evidence of a non-rheumatic origin.

Mitral stenosis is occasionally found in arteriosclerotic cases and in interstitial nephritis, a fact which has suggested an arterial origin for some of the cases. In 542 autopsies, in cases of interstitial nephritis, Pitt found mitral stenosis thirty-three times, and other writers have recorded the association of the two conditions.

In most if not all instances of rheumatic endocarditis, there is some narrowing of the mitral orifice, but it is only when this is considerable that the signs become distinct.

Anatomically the valve curtains are rigid, thickened, and adherent, and form a diaphragm perforated by the mitral orifice, which is reduced to a narrow slit-like opening, often termed the "button-hole" orifice. Less commonly the valves project in a funnel-shaped fashion toward the ventricle. The chordæ tendineæ are thickened and adherent, while a deposit of calcareous salts is frequent in the valve and even in the chordæ themselves.

The secondary changes are seen first in the left auricle which becomes hypertrophied and often dilated. According to Samway's observations hypertrophy is the primary change, dilatation occurring later. He found that cases of stenosis dying from cardiac failure presented, in addition to hypertrophy, a marked degree of dilatation, whereas those dying from surgical diseases or affections apart from the heart usually showed hypertrophy only.

The state of the left ventricle varies greatly. Theoretically it is argued that the diminished quantity of blood passing through the narrowed orifice cannot induce hypertrophy or dilatation, and that the ventricle remains of normal size or even undergoes a certain degree of atrophy. This view is certainly correct for some cases; at the same time hypertrophy is seen in a considerable proportion of cases, and according to Baumbach, who enters into this question very fully, a moderate degree of hypertrophy is present in almost all cases. Mitral regurgitation may be regarded as responsible for this hypertrophy in some instances, while in others there are pericardial adhesions or arteriosclerosis. The cavities of the right side undergo a marked degree of dilatation and hypertrophy, and the contrast between the enlarged right ventricle and the small left is sometimes very striking.

Symptoms.—Some degree of dyspnea is almost always present on exertion, and this with palpitation may continue for years. When the disease dates from childhood there is frequently a stunted growth, the chest is ill-developed, and there is diminished physical and mental vigor. The lips are often of a deep blue tinge, and in old-standing cases there is sometimes clubbing of the nails of the fingers and even of the toes.

As compensation fails dyspnea becomes more and more troublesome, and signs of venous stasis similar to those seen in mitral incompetence are found in the various organs. Pulmonary symptoms are common and these patients are very subject to recurring attacks of bronchitis.

Attacks of hemoptysis occasionally occur, and, unless due to infarction, often have a beneficial effect, relieving pulmonary congestion and the embarrassed right heart. Other signs of venous congestion are observed in recurring attacks of epistaxis from which some patients suffer, while hemorrhoids or menorrhagia occur in others.

Dropsy of the extremities is seldom a prominent feature, and any edema present is usually slight. Signs of a venous obstruction often fall chiefly or exclusively on the portal system, and hepatic enlargement or even cirrhosis may be present with ascites, in cases which show little or no edema of the lower extremities.

Welch (Trans. Am. Phys., 1900) has called attention to venous thrombosis in cardiac disease, occurring in serious failure of compensation, and more particularly in mitral stenosis. The veins affected are most frequently those conveying blood from the neck and upper extremity, and more commonly on the left than the right side. The peculiar localization of the thrombosis is to be attributed to the greater length and obliquity of the left innominate vein, and to pressure, direct or indirect, on the left subclavian vein from the dilated left auricle and pulmonary veins.

Symptoms of ruptured compensation often first appear during pregnancy or labor, or follow parturition; alarming or even fatal attacks of pulmonary edema sometimes appear, or persistently rapid action of the heart leading to asystole. Pregnancy is a complication in which there is always serious risk, although in favorable cases there is little or no disturbance. Subsequent pregnancies are sometimes passed without special difficulty, when earlier ones had caused great disturbance.

Hysterical manifestations are not uncommon in the course of mitral stenosis, both conditions being common in young women. Cardiac symptoms often predominate, and severe attacks of pseudoangina, of palpitation, or of dyspnea may occur in well-compensated cases. Without a correct appreciation of the neurotic element in such individuals these symptoms may lead to undue alarm.

Embolism is more common in this than in other forms of valvular lesions. If it occurs in the brain this accident shows itself in the form of hemiplegia, and if the embolus lodge on the left side, there will be aphasia.

The physical signs when well marked are extremely characteristic, but in the advanced stage of the disease they are often indefinite or equivocal. The more important are: the presystolic thrill and murmur, the snapping first sound, the accentuated pulmonary second, and evidence of enlargement of the right heart.

The pulse is small, somewhat increased in rate, and often of good tension; it is usually regular until a late stage of the malady, when extreme rapidity and arrhythmia may set in. The thrill, which is one of the most characteristic signs of the disease, is felt at the apex, and when the heart is not unduly rapid it is readily made out distinctly to precede the systolic impulse. It is sometimes prolonged, running through the whole diastolic interval, or it may immediately precede the impulse, and is then strictly presystolic. When present it is pathognomonic of stenosis. The cardiac impulse often gives the impression of a jet of liquid being projected against the hand. The murmur in typical cases is loud and rough, and is commonly compared to the sound "rrrb." It runs up to and terminates in a loud, abrupt, and snapping first sound. The murmur may be prolonged through the diastolic interval, but in the great majority of instances it occurs at the end of this period. In either case it is usually spoken of as the presystolic murmur. The murmur is in most instances localized at or about the apex, although, as pointed out by Griffiths, it is sometimes transmitted to the axilla or even heard in the back. The murmur is sometimes represented by a mere rumble, and in the absence of the snapping first sound is easily missed by the untrained ear. With advancing cardiac weakness or in the extreme irregularity due to auricular fibrillation, both thrill and murmur often disappear. A systolic murmur is frequently present, due to associated incompetence. It may persist when the thrill and presystolic murmur have disappeared.

Hardly less characteristic than the murmur is the

abrupt snapping first sound in which it terminates. It is often mistaken for the second sound, but the distinction can be made by noting that it is synchronous with the apex impulse. The second sound is often lost at the apex, and is sometimes reduplicated at this region; in the pulmonary area it is accentuated and even ringing, losing these characters with failing power in the right ventricle. With high tension in the pulmonary artery, a faint, whiffling, diastolic murmur is occasionally heard. This is regarded by Gibson and others as due to a temporary incompetence at the pulmonary orifice.

Evidence of enlargement of the right heart is often present, as shown by the increased impulse over the lower sternal region, and by an extension of dulness to the right border of the sternum or beyond, reaching in extreme cases as far as the right nipple line. With failing compensation and particularly in advanced stages of the disease the thrill and murmur often disappear, and the lesion is readily overlooked. A sharp first sound, evidence of enlargement of the right heart, sometimes a gallop rhythm, together with a small pulse should suggest stenosis, and with recovery the thrill and murmur often reappear.

Diagnosis.—A presystolic murmur is occasionally heard in conditions other than mitral stenosis.

The Flint murmur has already been referred to under aortic incompetence. In an adherent pericardium and in vegetative endocarditis of the mitral valve, a murmur of this character is sometimes found, usually of the low rumbling variety rather than of the loud and rough character. Ewart and Rutherford have recorded a case in which all the typical signs of stenosis were present and in which the autopsy showed a fibrinous polyp hanging from the auricle through the mitral orifice.

Tricuspid Regurgitation.—Regurgitation at this orifice is very generally admitted to occur in health, resulting from conditions, such as violent exercise, which temporarily raise the blood pressure in the pulmonary circuit. This is often spoken of as the safety-valve action, preventing the lungs from becoming unduly congested.

In the great majority of instances, tricuspid incompetence is the result of dilatation of the right ventricle, inducing relative incompetence at this orifice; in only a comparatively few cases does the lesion depend on organic changes in the valves.

Dilatation of the right ventricle is always a secondary process. It constantly occurs in old-standing mitral lesions, and as the result of obstruction in the pulmonary circuit, from emphysema or fibrosis of the lungs. In dilatation of the left ventricle, from whatever cause, the right ventricle is commonly included in the morbid process.

The valve may be affected by endocarditis, acute or chronic, or by degenerative changes. Under these circumstances the valves of the left heart are almost invariably the seat of similar lesions. In malignant endocarditis, the valve is occasionally affected alone. In thirty-nine instances, Pitt found ten in which this valve was alone attacked.

Symptoms.—These are similar to those found in mitral disease, and consist in breathlessness, with evidence of obstruction in both the systemic and the portal venous systems.

Physical Signs.—A systolic bruit is sometimes heard in the lower sternal region, having its maximum intensity just to the right of the sternum about the fourth and fifth ribs, and occasionally transmitted to the right as far as the parasternal line. It is not heard at the apex, although it may be difficult to differentiate it from a coexisting mitral murmur. In some instances a difference in timbre may be noticed. Owing to a debilitated condition of the right ventricle the murmur may be absent even in well-marked cases, and again, it may disappear under the influence of rest and digitalis. The enlargement of the right ventricle causes increased pulsation in the epigastric and lower sternal regions. Dulness extends to the right border of the sternum or for two or three finger-breadths beyond, although it is frequently masked by emphysema.

Pulsation in the veins, accompanying each systole of the heart, forms important evidence of the condition under discussion. It depends on a reflux of blood in the dilated veins after their valves have become incompetent. It is seen in the external and internal jugulars, and sometimes even in more distant veins, such as the brachial. Care must be taken not to confuse true venous, or, as it is sometimes termed, positive pulsation, with certain undulatory movements of these vessels. If the vein is emptied from below, positive pulsation continues.

Venous pulsation is also observed in the liver. The enlarged organ, grasped between the hands, presents a true expansile pulsation, and not merely a transmitted epigastric impulse from an enlarged right ventricle.

Tricuspid Stenosis.—This condition, although rare, is more frequent than are lesions at the pulmonary orifice. Pitt found it eighty-seven times in 12,000 autopsies.

Congenital stenosis is not uncommon in still-born children, or in those who have lived a few days. It is frequently associated with other cardiac abnormalities or defects.

It has been asserted that almost all cases are of congenital origin, but this view is not borne out by statistics. In Pitt's series of 87 cases, only one patient died under ten, and in Herrick's tabulation of 40 cases the youngest patient was twelve years old, with a history of acute rheumatism two years previously, facts which strongly suggest an acquired origin. In the great majority of cases, tricuspid stenosis is associated with a similar process in the mitral, and often with disease of the aortic segments as well. In Leudet's series of 114 cases the tricuspid valve was affected alone in only one instance, and in Herrick's once in 40 cases. Females are affected about four times as often as males. A history of acute rheumatism was present in 10 or 25 per cent. of Herrick's series, chorea in 2, doubtful rheumatism in 4, no rheumatism in 9, and in 15 there was no record. In Pitt's cases, however, rheumatism played a predominant rôle in the etiology.

A fatal issue usually results under thirty years of age, and in only twelve cases out of 151 (Leudet's and Herrick's series) did the patient reach the age of fifty. The symptoms are those of mitral stenosis of the most pronounced form. Dyspnea and cyanosis are often extreme, and Broadbent regards pronounced dropsy as evidence of the disease. The diagnosis has been made in a few instances during life, but in the great majority of cases it has been overlooked.

A presystolic murmur and snapping first sound heard at the ensiform cartilage or a little to the right, and fading off and again becoming marked at the mitral, has been correctly interpreted as indicating stenosis of both orifices, and in a few cases a thrill has been detected in the tricuspid region. The murmurs in the tricuspid and mitral regions have also been noted as having a different character, but the characters of the cardiac sounds are often rendered difficult of interpretation owing to rapid or irregular cardiac action. The heart is enlarged to the right as in mitral stenosis, while both the venous and the hepatic forms of pulsation are often present owing to associated tricuspid regurgitation.

Pulmonary Orifice.—Disease of the pulmonary valves is usually congenital, and is then commonly associated with other cardiac anomalies. Only a few of these cases reach adult life.

The majority of acquired cases are due to malignant endocarditis. Congenital absence of one of the cusps

may lead to sclerotic processes in later years, as in aortic disease.

Acute rheumatism is not a frequent cause, being present in only seven of twenty-nine cases collected by Gerhardt.

Obstructive disease is difficult to recognize owing to the frequent occurrence of systolic murmurs in the pulmonary area from other causes. A distinct thrill, a harsh murmur, and evidence of enlargement of the right ventricle are the signs which may be found, but similar signs may be caused by the pressure of an aneurysm or tumor on the trunk of the vessel.

Incompetence gives rise to a diastolic murmur in the pulmonary region, often louder during expiration, and transmitted down the left sternal border. It is not heard toward the apex or in the vessels of the neck.

Enlargement of the right ventricle is usually considerable and the apex is pushed to the left. There is an absence of the arterial phenomena of aortic disease, but Gerhardt has shown that graphic representations of the pulmonary pulsations show analogous changes. By introducing a manometer into one nostril, closing the opposite one by pressure, and directing the patient to cease breathing, he obtained a tracing showing larger excursions of the lever, and a more sudden rise and fall than is obtained either in health or in aortic incompetence.

Cyanosis, venous enlargement, and pulmonary embolism have also been noticed in disease of this orifice.

Tuberculosis is not an uncommon mode of death, and is attributed to the anemic condition of the lungs.

Combined Valvular Lesions.—In a large proportion of cases more than one valve is affected, or there may be both incompetence and obstruction at one orifice. The general features and signs usually point to predominant disease of one valve. Aortic and mitral incompetence are often associated, while mitral stenosis is frequently accompanied by slight sclerosis of the aortic segments, having no clinical significance.

Prognosis of Valvular Disease.—The prognosis is based partly on an estimate of the extent and character of the valvular lesion, partly on the general health and habits of the patient.

Aortic incompetence is usually regarded as the most serious of valvular affections. The arteriosclerotic cases, owing to the frequency with which the coronary vessels are involved, are more serious than stationary rheumatic conditions. Of the valvular affections, aortic incompetence is the one in which sudden death is most apt to occur. Favorable features are a moderate degree of cardiac enlargement, a pulse not showing the collapsing character to a high degree, a distinct second sound in the arteries of the neck, and an absence of cardiac symptoms. According to N. S. Davis the average duration of life after compensation begins to break down is 3.8 years, a period which closely corresponds to Balfour's estimate of four years.

Aortic stenosis is usually regarded as the least serious of valvular lesions. In moderate grades of the disease but little disturbance of function takes place. More serious, however, are the cases with evidence of a high degree of stenosis, as shown particularly by the pulse. Arteriosclerosis always suggests the possibility of disease of the coronary arteries, and anginal attacks convert such a suggestion to a certainty.

Sudden death is rare, although it may occur from disease of the coronary vessels, and has also resulted from occlusion of an extremely narrowed orifice.

Mitral lesions are on the whole less serious than aortic regurgitation. Stenosis is usually regarded as a more serious affection than incompetence. Osler regards the latter as almost as serious as the former.

In many cases in which a mitral systolic murmur is heard at the apex, this lesion shows no tendency to shorten life, and in the absence of cardiac symptoms, and of other signs of cardiac disease, its presence may be regarded with but slight apprehension. More serious are the cases in which a considerable degree of regurgitation is revealed by marked enlargement of the ventricle, but even here the patient may enjoy a long period of good health, provided that symptoms of cardiac disturbance are absent.

A cardiopulmonary murmur is not uncommon at the apex, and is heard best or exclusively at the end of inspiration. It is frequent in pulmonary tuberculosis, and in the absence of other evidence of cardiac disease may be disregarded.

The mere loudness of a murmur is in itself no index to the severity of the lesion. Very soft murmurs are often heard in failing hearts, while loud rasping murmurs, although indicative of valvular damage, may be present with perfect compensation.

Mitral stenosis is not incomparable with longevity, but in most cases there is a marked shortening of life. Broadbent found the average age at death to be thirty-three years in males and thirty-eight in females, and other estimates agree closely with this. Of other influences affecting the duration of cardiac disease experience shows that children bear these lesions badly, and such cases frequently terminate fatally at or shortly after puberty. Females bear valvular disease better than males, a fact which is probably to be attributed to their less active habits and to their less frequent indulgence in alcoholic excess. An exception to this rule is sometimes seen as the result of pregnancy, in which the increased strain occasionally results in serious and even fatal cardiac failure.

Laborious occupations are unfavorable, as are also sexual and alcoholic excess, and the free use of tobacco.

Finally poor general health, anemia, recurring attacks of bronchitis, hepatic and renal engorgement, and pulmonary embolism are all unfavorable signs.

Recurring attacks of rheumatism often exert a most unfavorable influence owing to fresh attacks of endocarditis, and in children rheumatic inflammations occasionally progress to a fatal issue within a few weeks or months.

Acute disease, particularly pneumonia, is often ill borne, and if survived is sometimes followed by loss of compensation. I have known several cases of mitral stenosis date their symptoms from an attack of pneumonia.

Treatment.—During the period of compensation no very active treatment should be directed toward the heart.

It is important in this stage to keep the general health up to the best possible point. For this purpose the diet should be plain and nourishing, and the coarser vegetables should be avoided as tending toward flatulence. Alcohol is unnecessary in young people, and if used at all should be taken in strict moderation with food. Tobacco is injurious, while tea and coffee must be avoided should they cause any cardiac palpitation or uneasiness.

In rheumatic cases special care should be taken to see that the patient is suitably clad, and even with slight rheumatic manifestations he should be confined to bed or the house. When there is reason to believe that syphilis is the etiological factor, an exception should be made to the statement that active treatment is unnecessary during the stage of compensation. Active measures, including the use of salvarsan, mercury, and iodide of potassium should be employed. Unfortunately many cases of vascular syphilis are extremely refractory to treatment and the Wassermann test frequently continues positive in spite of the most active use of these remedies. There are cases, however, where marked improvement occurs, and it is reasonable to assume that extension of the morbid condition may be checked, even when the resulting danger to the heart is beyond repair.

Exercise and athletics are beneficial provided they cause no undue fatigue or are not pushed to the point of inducing dyspnea. The more violent forms of exercise such as football or even tennis should be forbidden, but golf, mild bicycling, or rowing and walking are safer, inasmuch as they throw much less strain on the heart. In cases in which for any reason it is judged unwise to allow even easy exercise, rest in the open air is beneficial.

Medicinally, an occasional aperient should be given. Tonic doses of iron or arsenic, particularly when anemia is present, or strychnine are valuable. Small doses of digitalis (♏ v. to x. of the tincture) may be administered should any tendency to dyspnea or palpitation exist, and the use of this drug is sometimes continued for lengthened periods with decided benefit.

When compensation begins to fail, and dyspnea, dropsy, and palpitation become marked, a more active plan of treatment is required.

In most instances of uncomplicated valve lesions failure of compensation is due to dilatation, brought about for the most part by excessive muscular work, although in some cases it is induced by severe mental strain. The first object is therefore to secure physical and sometimes mental rest. When the symptoms are at all severe, absolute rest in bed must be enjoined; and treatment by this method alone is sometimes sufficient to relieve dyspnea and remove dropsy. It is, however, advisable in most instances to use medicinal or other agents, which hasten recovery and alleviate distress.

Of the cardiac stimulants by far the most valuable is digitalis. This remedy slows and strengthens the muscular contraction of the heart, while the pulse rate is reduced and becomes more regular, the peripheral arteries are contracted, the renal arteries relax, and a large volume of blood passes through the kidneys as shown by the free diuresis.

In aortic incompetence the objection to digitalis is sometimes raised that it prolongs diastole and hence allows of freer regurgitation. This objection is largely theoretical, and many cases receive a marked degree of benefit from the increased muscular action; dyspnea is relieved, and in favorable cases compensation is restored. The remedy should be given cautiously and in small doses. It is in mitral disease, particularly when dropsy and dyspnea are present, that digitalis produces the most brilliant results. Dyspnea is relieved, free diuresis is set up, and dropsy lessens and disappears.

In mitral incompetence, not only is the muscle stimulated, but the regurgitation is lessened owing to the more perfect closure of the auriculoventricular ring. In stenosis the lengthened diastolic period allows more time for blood to pass from the engorged auricle through the narrowed valve.

In cases of extreme irregularity due to auricular fibrillation digitalis often exercises its most beneficial influence. Mackenzie believes that it is of real service only in such cases, but this view is probably too narrow. The drug should be continued in small doses after the heart has come under control and may be kept up with benefit for months or years or as long as the irregularity persists.

The action of digitalis is somewhat slow and it is not until the third day that the full effects of the drug are seen. When marked slowing of the pulse to 60 or under, or a fall in the quantity of urine occurs, the dose should be lessened or stopped, owing to the danger of toxic manifestations, which reveal themselves in the form of nausea and vomiting, weakness and irregularity of the pulse, or a double beat of the heart to one of the pulse.

The drug should be given freely for from forty-eight to seventy-two hours when the symptoms are at all urgent—say in doses of ♏xv. of the tincture or ℥iv. of the infusion every three or four hours. Smaller doses are usually sufficient (♏x.–xv. t.i.d.) in the absence of severe symptoms. Nausea and vomiting are sometimes produced by even moderate doses, and in such cases rectal administration of one or more large doses of the fluid extract are often extremely beneficial. Five or ten minims (♏i.–gr. i. digitalis) administered with starch in this way often act rapidly, and I have seen the pulse slowed and dyspnea relieved in the course of a few hours. An old and reliable preparation is Guy's pill, consisting of gr. i. each of digitalis, squills, and pil. hydrarg.

Strophanthus is a valuable substitute for digitalis. It acts on the heart like digitalis, but has not the same tonic effects on the arteries. It is consequently sometimes preferred in arteriosclerotic cases with increased arterial tension. It is inferior to digitalis in removing dropsy, but is sometimes of value in alleviating cardiac symptoms when this drug fails. Strophanthin in doses of $\frac{1}{250}$ to $\frac{1}{100}$ gr. is a valuable and powerful remedy in heart failure. The preparation should be administered intravenously or intramuscularly. In patients under the influence of digitalis the drug should not be administered owing to the risk of producing an untoward or even a fatal result. Sparteine acts in a similar manner to strophanthus, but as a rule is inferior to it.

Caffeine is occasionally useful as a substitute for digitalis. It sometimes induces restlessness and insomnia.

Strychnine is a much overrated drug, and although frequently used as a cardiac tonic has little or no influence on the heart.

Diffusible stimulants such as alcohol, ether, and ammonia are of value in emergencies, and until the more slowly acting stimulants affect the heart.

A dose of calomel, gr. v. with gr. x. of bicarbonate of soda, is often administered with benefit preceding the course of digitalis. It relieves portal congestion and engorgement of the right heart, and increases the efficacy of digitalis.

In arteriosclerotic cases the long-continued administration of iodides often proves of much value in controlling palpitation and other symptoms, possibly by lowering peripheral resistance. Nitroglycerin is also a valuable agent in lessening peripheral resistance and is often advantageously given with digitalis in doses of ♏i. of the one-per-cent. solution. Sodium nitrite gr. ii. to v. and erythrol tetranitrate are used as substitutes for nitroglycerin.

Obstinate or persistent symptoms often require special measures for their mitigation or relief.

Dyspnea continuing after the use of digitalis, and especially when nocturnal in character, is often relieved in a remarkable manner by a hypodermic injection of morphine, and in advanced cases this drug is invaluabl.

Sleeplessness sometimes yields to paraldehyde, trional, or sulphonal, but, as it is often dependent on dyspnea, these remedies are much inferior to morphine.

Pain over the cardiac region is often alleviated by the iodides, especially in arterial cases, or by nitroglycerin.

Dropsy may be diminished by free purgation. For this purpose calomel, salines, and hydragogues, especially compound jalap powder, are most serviceable. Sodium chloride holds the fluids in the tissues and a salt-free diet is often followed by a rapid diminution of the dropsical fluids.

Needle puncture of the distended limb with strict aseptic precautions allows considerable quantities of the fluid to drain away. Southey's tubes are also very efficacious, and there is considerable danger of inflammatory changes taking place in the subcutaneous tissues.

Theobromine in doses of gr. lx. to gr. xc. daily may be used with occasional benefit as a diuretic when the urinary secretion is persistently small.

When considerable quantities of fluid collect in the

abdominal or the pleural cavity paracentesis is necessary and may be repeated as often as required.

Palpitation is much relieved by an ice-bag over the precordial region. A diffusible stimulant, or strychnine in full doses often proves of signal service. If the attack is severe, a hypodermic injection of morphine may be given. Strict attention to diet together with quiet and rest is also essential. In cases where the neurotic element is marked bromides may prove serviceable.

Vomiting.—Food must sometimes be withheld for some hours, or replaced by sips of hot water, brandy, or champagne. After the vomiting has yielded or lessened, liquid food may be cautiously tried. Milk may be given freely diluted with lime water, Vichy, or effervescing waters, and peptonized beef essences are often tolerated when other foods are rejected. In obstinate cases rectal alimentation may become requisite. The frequent action of digitalis in inducing vomiting must be remembered in this connection. It must often be withheld for a period, but should not be given up without good reason.

Venesection is occasionally required when marked cyanosis or dyspnea is present, and ten, twenty, or even thirty ounces of blood may be abstracted from the arm. A valuable measure which has largely fallen into disuse is the application of a few leeches to the precordial region followed by hot fomentations to encourage bleeding.

During the past few years much has been written on the Nauheim methods, consisting in bathing in aerated water, and movements with resistance. The baths lessen the peripheral resistance, and the movements tend to empty the veins. Percussion and skiagraphs show a lessening of cardiac dilatation after application of these methods. They seem to be more successful at the natural springs than when applied in hospitals or other localities. FREDERICK G. FINLEY.

Heart, Wounds of the.—Wounds of the heart may be either non-penetrating or penetrating, injuring the cardiac wall, or opening a cavity. The left ventricle is most frequently injured, and the left auricle is least so.

On account of the wall being three times as thick and the columnæ carneæ larger and more numerous, the bleeding is less profuse in the left ventricle than in the right and, therefore, wounds are less dangerous. Auricular wounds are more fatal than ventricular because the walls are thinner and have less contractility. Wounds of the apex and interventricular septum, provided there is no injury to the coronary arteries, are less dangerous than either. A needle puncture will rarely cause hemorrhage from a ventricle, but excessive bleeding, which is mostly systolic, is liable to follow a like injury to an auricle. A wound inflicted during diastole is less dangerous than a similar injury during systole, and perpendicular wounds are more fatal than diagonal. The presence of the foreign body in the heart, the size of the wound, the location of the wound, the number of wounds, the connecting cavities, the attending syncope, the involvement of Hugo Kronecker's coordination center or Walter Gaskell's bridge, and the degeneracy of the cardiac muscle are important factors in determining the outcome.

Pericarditis, myocarditis, endocarditis, traumatic valvular disturbances, cerebral embolism, pulmonary embolism, and empyema frequently are secondary complications. When the wound heals spontaneously there is a possibility of cicatricial stretching, cardiac aneurysm and subsequent rupture for as Matas says, "true myocardial regeneration is largely prevented in the unsutured cases by the greater size of the organized thrombus, which fills the wound tract. Therefore the cicatrix in a spontaneously healed wound remains as a locus minoris resistentiæ, which is always a menace to the patient's life." Izzo reported a case of a man stabbed in the left ventricle, who was conveyed to the hospital, from which he was discharged as cured on the twenty-eighth day; a few hours afterward, while lifting a heavy body, he fell and quickly died. At the autopsy the cicatrix of the left ventricle was found ruptured. Loison has collected nine such cases. In addition to the injuries caused by bullets, daggers, knives, needles, and various implements of war, the heart may be wounded by a fractured rib, by a foreign body that has perforated the œsophagus, or by blows upon the chest. Bernstein reports eight cases in which the force was sufficient to separate the heart entirely from the body.

Traumatic ruptures are more frequent after a full meal, as the distended stomach pushes the heart upward and forward, and causes a large area of the organ to be in contact with the thoracic wall, and therefore receive the impact. Newton and Gamgee have collected forty-five cases in which traumatisms caused rupture of the heart without opening the pericardium. All were fatal. Only one of Gamgee's cases survived the injury fourteen hours. The fatality is easily understood, for, there being no exit, as soon as the accumulation of blood exceeds the limit of pericardial distensibility the cardiac movements are mechanically stopped. The surgeon not only would be justified, but it is his bounden duty to operate upon every one of these cases, for it is more important, if possible, to rescue a drowning heart than to relieve a strangulated hernia.

Pathological rupture of the heart may occur anywhere, but is usually found in the left ventricle near the septum, and may be due to fibroid and fatty degeneration, suppurative myocarditis, myocardial gumma, echinococci or aneurysmal dilatations. The general condition of the patients and their myocardial degeneracy place them beyond the utmost reach of human help. It is possible for a foreign body, as a gun missile, to remain quiescent for years in the myocardium, as in the case of a British officer, reported by Stevenson, who carried a bullet encapsulated for eleven years, or the still more remarkable case of Beers (*Lancet-Clinic*, 1898) of an American soldier who survived the lodgment of a bullet in the wall of the left ventricle for thirty-seven years. They can be easily located by radioscopy and should be removed if exerting a baneful influence.

SYMPTOMS.—There is no certain cardinal sign by which an injury of the heart can be denoted; but when we consider the location of the external wound and, if large, the usually profuse hemorrhage from it, which may spurt, in connection with pain, pallor, and restlessness, and generally dyspnea, it can usually be recognized. More frequently the bleeding is internal and, the pleura being also wounded, the blood runs into the pleural cavity, producing acute anemia with the additional symptoms of an increasing pneumohemothorax, with Nietert's characteristic splashing sound. If the opening is small the bleeding is practically confined to the pericardium and we have grave cardiac disturbances from compression. The pulse is weak, irregular, intermittent and often imperceptible in the extremities. Discoloration of the face, engorged and beating jugulars bespeak auricular compression. Often the apex cannot be detected and the heart sounds are distant and frequently imperceptible. Percussion elicits increased dullness of a triangular shape. Bulging of the thoracic wall is observed in many cases. Cardiac tamponade does not necessarily mean that there is an injury of the heart, as it may occur when the pericardium is opened along with a wound of the internal mammary vessels, pericardial vessels, coronary or any vessels within the fibrous sheath. The *x*-ray furnishes valuable assistance, since it shows an enlargement of the cardiac outline and the presence of any foreign body, as in a case

that came under my observation. In children the heart is an intercostal space higher than in adults. In the fourth, fifth, and sixth intercostal spaces near the left edge of the sternum the heart comes close to the surface and can be easily injured. Frequent attacks of syncope are common. The mind is usually clear, but the countenance depicts an anxiety and distress that seemingly would welcome death, with the wintry sterility of the grave, as a sympathizing friend. With the pulsation of the heart a foreign body, as a needle, may be seen to move under the skin—a symptom, centuries ago, enshrined in the magnificence of indestructible verse,

"He fell, the spear point quivering in his heart,
Which, with convulsive throbbing, shook the shaft."

Prognosis.—The chief dangers are shock, hemorrhage, and infection. Ninety per cent. are penetrating, and of these only nineteen per cent. are instantly fatal. The statistics of Rehn show that of seventy-five deaths in the operative cases, sixteen occurred on the operating table or within the first hour after the operation, and seventeen from seven hours up to two days, which makes a mortality of forty-four per cent. from hemorrhage and collapse. Thirty died as a consequence of infection, which is forty per cent. Therefore, eighty-four per cent. of the seventy-five patients died of hemorrhage and infection. In nearly all of the infective cases the patients died of purulent pericarditis or empyema. In twelve of these the pericardium was primarily closed. Of 124 cases of heart suture there were forty-nine recoveries, or about forty per cent. One hundred and nine were stab wounds, with forty-three recoveries, or about thirty-nine per cent., and fifteen gunshot wounds, with six recoveries, or about forty per cent. Loison claims that one-third of the gunshot cases die within an hour after the injury and hence the infrequency of suturing. Fifty-five times the left ventricle was penetrated, with twenty-five recoveries, or forty-five per cent., and fifty times the right ventricle with sixteen recoveries, or thirty-two per cent. The right auricle was involved in four cases, the left in three cases, one case the septum, without penetrating the ventricles, and in eleven cases Rehn failed to give the location of the wounds. Perforations of the auricles are so infrequent that no reliable statistics have been gathered, but we are safe in assuming a much greater mortality.

Treatment.—I presume no one will question the propriety of immediate operative interference, as experience teaches that about forty per cent. of cases recovered in which the heart had been sutured as against ten per cent. of recoveries in which no operation had been performed. According to Rehn there is not a single death attributable to surgical manipulation; and though sixteen patients have died upon the table, other causes were obvious. In the case of a girl sixteen years of age Podrez probed the left ventricle for a bullet, made ten insertions with a needle, and kneeded the organ with his entire hand, using considerable force, in a vain effort to locate the missile. During his search no interruption of the heart beat occurred and the girl recovered. Hesse reports an interesting case in which he found that the heart had stopped in diastole, and massage was without result, but the contractions were reestablished by the injection of camphor into the heart musculature, and the patient lived seven hours.

A needle should be removed at once, but a knife blade or dagger must not be touched until the surgeon has bared the heart and is master of the situation, since an uncontrollable hemorrhage might occur, as in the case of the late Empress of Austria when a file was unfortunately extracted prematurely. It seems hardly necessary to accentuate the fact of the necessity of perfect asepsis in this operation, as forty per cent. of deaths are due to infection. Diminished resistance from loss of blood and want of cleanliness from hurry of preparation are largely contributive causes. Until every aseptic precaution has been taken mechanical stoppage of the heart from blood in the pericardium should be prevented by aspirating. If the escape of blood in the pericardium is very rapid, seven ounces may be sufficient to cause death; but if gradual, a much larger quantity will be tolerated. Moullin reported a case in which "the pericardium contained six pints of thin dark fluid which was removed and the patient recovered." The needle passed through a flame is rendered aseptic and made to enter the sixth left space close to the sternal margin, the thickness of the bone, about one-third of an inch, then behind the sternum for half an inch, to escape the pleura, and raising the handle push the needle downward into the pericardial sac—travelling a little more than two inches. The operation has a mortality of a little the rise of one per cent.

In case of unconsciousness with hardly a sign of life, we should operate without an anesthetic; and upon the return of consciousness administer ether by the drop method. Matas contends that artificial respiration with mechanical contrivances is injurious until after the heart has been sutured because the collapse of the lung materially diminishes the hemorrhage, but are of decided value in the terminal stages of the operation. In this opinion Sauerbruch and Haecker do not share but recommend their use *ab initio*. Some surgeons prefer an exploratory pericardiotomy in doubtful cases which can be easily extended should cardiorrhaphy become necessary. Either Kocher's or Ollier's operation may be selected. Matas is inclined toward C. B. Porter's procedure which is practically the same as Ollier's. "An incision is made from the middle of the sternum outward over the fifth costal cartilage to its junction with the rib. The soft parts are cleaned from the cartilage with the periosteum elevator, care being taken not to wound the pleura on the under surface. The cartilage is removed with bone forceps. The mammary artery and vein are thus exposed, ligated in two places, and divided. A little careful dissection with the director, in case fat is encountered, exposes the pericardium, which is normally much thicker than the pleura." Many operators, including the illustrious names of Salomoni and Rehn, recommend Spangaro's operation as "the quickest and safest route to the pericardium and the heart." Spangaro makes his incision in the middle of the fifth left intercostal space, to avoid the intercostal vessels, and ligates the internal mammary vessels which lie upon the triangularis sterni muscle about one-half an inch from the sternal border. Rarely is it necessary to go outward beyond the anterior axillary line. The cartilages are divided at the joints, above or below, from the second to the sixth according to the location of the wound. Retracting the musculo-osseous flap a splendid view is obtained. Should more space still be required the sternum may be divided but one must be careful not to open the right pleura. Professor Rotter of Vienna performed a number of experiments upon the cadaver and concluded that the easiest way to expose the heart was by making an incision four inches in length along the lower border of the third rib, commencing three-fifths of an inch to the left of the sternum. A similar incision was made along the lower border of the fifth rib. The external ends of these incisions were joined by a third. The fourth and fifth ribs were divided and the musculo-osseous flap was turned inward. If more space should be required the third could be included. This operation gives us an opportunity of easily removing any extravasation of blood and inspecting the pleural cavity, with reference to other injuries. In ninety per cent. of cardiac wounds the pleura is involved. A simple intercostal incision will not do, for it is absolutely necessary to have a musculo-

osseous flap containing one or more ribs, if the operation is to be performed quickly and thoroughly. If there is slight bleeding from the heart it may be controlled with a stitch, by pressure of the finger or by the introduction of a finger, as Parrozzani did. Some times the bleeding is so profuse that suturing is impossible, but if the heart is pulled outward and turned to the right the bleeding will cease because the vessels are flattened and twisted. This harsh method causes great distress, but no death has been recorded from it. The operation can be made bloodless by compression of the right atrium. Professor Magnus of Heidelberg experimented upon dogs and demonstrated that a dog's heart would stand incomplete compression up to four minutes, and complete one and a half minutes; and Rehn thinks the human heart would be much more tolerant as it is not nearly so irritable as the dog's. Experiments upon animals have shown the brain less tolerant than the heart to the effects of the ischemia. With the right hand gently lift the heart out of the pericardium and introduce from below the left hand, and immediately we feel the vena cava inferior, and its inosculation into the right atrium which should be pressed between the index and ring finger, and pushing upward we displace the inosculation of the vena cava superior. Rehn truthfully remarks "we have in the compression of the right atrium venosum a means of bringing the most violent heart bleeding to a stop at once."

In suturing, do not include the endocardium, be certain to get a good hold lest a brittle heart give way. I prefer the interrupted catgut stitch and to use an intestinal needle. Should the heart appear weary allow it to glide back into its normal position for a few moments. As few stitches as possible should be passed, commensurate with safety against leakage, as they cause a degeneration of the muscular fiber with its tendency to dilatation and rupture. Giordano, from his experiments upon rabbits, prefers Lembert's sutures in closing an auricular wound. The sutures should be passed and tied during diastole. Tubes are preferable to gauze for drainage as the latter is liable to cause a retention of the discharge and strangulation of the organ. Never close a pericardium with an open pleura because of the ease of infection in the latter which may extend to the pericardial wound and cause the formation of pus in the closed pericardium. Rehn advocates closure of the pleura and tubular drainage of the pericardium. The tube should be removed between the second and fourth day. Hesse found the most frequent untoward end results of heart suturing to be due to cardiopericardial adhesions, and advises against drainage of the pericardium. The after-treatment consists in absolute quietude, giving small doses of morphine when necessary. Hypodermic injections of strychnine, digitalin, and camphor are beneficial. Proctoclysis after Murphy's method is recommended. Intravenous injection of a saline solution must be used with great caution for fear of acute dilatation.

Conclusions.—From my own experience with four cases and a careful review of 250 reported by others I have drawn the following conclusions:

1. That any operation which reduces the mortality of a given injury from ninety to sixty per cent. is entitled to a permanent place in surgery, and that every wound of the heart should be operated upon immediately.

2. Whenever the location of the external wound and the attending symptoms cause suspicion of a wound of the heart, it is the duty of the surgeon to determine the nature of the injury by an exploratory operation.

3. Unless the patient is unconscious, and corneal reflex abolished, as in Pagenstecher's case, an anesthetic should be given, and preferably ether, by the drop method. Struggling is liable to produce a detachment of a clot, and renew the hemorrhage, as occurred in Parlavecchio's patient.

4. Never probe the wound, as serious injury may be inflicted upon the myocardium.

5. Either Spangaro's or Rotter's operation renders access to the heart extremely easy, gives an opportunity of removing any extravasation of blood, and permits inspection of the pleural cavity with reference to the injuries.

6. Steady the heart before attempting to suture it—either by carrying the hand under the organ and lifting it up, if the hole is large enough, introducing the little finger, as Parrozzani did, which will serve the double purpose of stopping the bleeding and facilitating the passage of the stitches.

7. When the hemorrhage is so profuse as to preclude the possibility of suturing, with the right hand gently lift the heart out of the pericardium and introduce from below the left hand and press between the index and ring finger the vena cava inferior and its inosculation into the right atrium and pressing upward displace the inosculation of the vena cava superior.

8. Professor Magnus of Heidelberg believes that the heart will stand complete compression for a minute and a half and incomplete for four minutes.

9. Catgut sutures should be used, as wounds of the heart heal in a remarkably short time. The sutures should be interrupted, introduced, and tied during diastole, not involving the endocardium, and as few as possible should be passed commensurate with safety against leakage, as they cause a degeneration of the muscular fiber with its tendency to dilatation and rupture.

10. In cleansing the pericardium, it should be sponged out and no fluid poured into the sac, as quickly produced tension may cause serious consequences to an already disabled heart.

11. Until every aseptic precaution has been taken, the mechanical stoppage of the heart from accumulation of blood in the pericardium should be prevented by aspiration, as diminished resistance from loss of blood and want of cleanliness from hurry of preparation are largely contributive causes to the forty per cent. of deaths from infection.

12. Rehn suggests closing the pleura and draining the pericardial sac, but never the reverse, because of the ease of infection of the pleura, which may extend to the pericardial wound and cause the formation of pus in the closed pericardium.

13. For drainage, tubes are preferable to gauze, as the latter is liable to cause retention of the discharge and may strangulate the heart.

14. A needle may be removed at once, but a knife blade must not be touched until the surgeon has bared the heart and is master of the situation, as an uncontrollable hemorrhage might occur from premature extraction. L. L. Hill.

Heart-block.—See *Arrhythmia.*

Heart-strain.—See *Heart, Functional Disorders of.*

Heat, Animal.—The heat of the animal body is the result of the oxidation of the food stuffs. This oxidation takes place in the tissues of the body and is subject to variations according to the requirements of the tissues for energy. Oxygen is carried to the tissues by the blood—for the most part in combination with the hemoglobin of the red corpuscles. The food stuffs are likewise carried to the tissues by the blood, but in solution in the plasma. Under certain forms of stimulation the cells receiving both oxygen and food activate the oxygen and cause it to unite with certain chemical groupings derived from the food and the result is the liberation of energy which takes one of three forms: mechanical work, electrical currents, or heat.

By far the greater part of this energy takes the form of heat; for, at the best, *i.e.* working under the most favorable conditions, the tissues are unable to convert more than one-third of the potential energy of the food into mechanical work; and, ordinarily, the amount so converted is not more than one-tenth. The amount taking the form of electrical energy is almost infinitesimally small.

It is sometimes stated that the heat which results from oxidation in the animal body is simply a by-product of the internal work which takes place in the tissues. This can scarcely be a correct conception of the process of oxidation as a fundamental life process, especially in warm-blooded animals; for the maintenance of a temperature well above that of the surrounding medium is an essential condition for the performance of the internal work (chemical reactions) in the tissues. It is fair to say, therefore, that the production of heat at a rate sufficient to offset the inevitable loss to its surroundings is a necessary function of every warm-blooded animal. The evolution of heat, however, is not confined to the higher animals but is common to all living beings. It is very evident, for example, in the germination of seeds, and in a hive of bees the temperature of the atmosphere is often 10° above that of the surrounding atmosphere.

Increased activity in living tissues is almost invariably accompanied by an increased evolution of heat. Since this heat is derived from the chemical changes which proceed in the living cells, and since all chemical processes are quickened by a rise of temperature, we should expect to find that the heat produced in the metabolic processes of the organism would tend of itself to quicken these processes. This is found in fact to be the case. In most chemical reactions a rise of 10° C. would increase the velocity of the reaction from two and a half to three times (Van't Hoff's Law), and the same law is, within the limits of stability of living tissues, found to apply to the process of oxidation. For example, in the early growth of a lupine seedling, it has been found that the output of CO_2 bears to the temperature the following relationship:

0° C.	6 milligrams per hour
10° C.	18 milligrams per hour
20° C.	44 milligrams per hour
30° C.	86 milligrams per hour

The same relationship has been found to obtain for the production of CO_2 in the snail, the leech, and the earthworm. Perhaps the absorption of oxygen is a still better measure of the heat production. Within the range of 5 to 21° C. it has been observed that the factor (Q 10), which, in biological literature, expresses the number of times a process is accelerated for a rise of 10°, has, for the absorption of oxygen by the crayfish, a value of 2.5 to 3.5. In the case of the leech the same factor, between 10 and 24°, is from 2.4 to 3.0.

In living things the range within which any such law applies is necessarily very narrow as compared with its range in inorganic reactions; and the factor (Q 10) varies, according to the best determinations which have yet been made, very widely. Nevertheless, it may be said that the law that the rate of chemical change (metabolism) varies with the temperature of the living substance is a universal law for all animals and plants. As applied to the production of heat in living things this law would result in a vicious circle (the temperature increasing the oxidation and the oxidation increasing the temperature) which would rapidly destroy the living substance itself, if special mechanisms did not exist for the removal of the heat. Where these mechanisms break down, as in fevers, the heat must be removed by artificial means. Cold-blooded terrestrial animals are protected from such a result by the fact that, the skin being kept moist, any increase in the heat production causes greater evaporation of water from the surface and hence a correspondingly greater cooling effect. Most such animals also burrow into the ground or take to the water in very warm weather, while, in plants, a rise of external temperature increases the transpiration of water through its leaves even more than it increases the oxidative processes; hence, their temperature is commonly several degrees below that of the surrounding atmosphere.

Animals Classified According to Body Temperature.—When compared with respect to their dependence upon the external temperature, animals fall into two classes. An animal whose body temperature follows or closely approximates that of its surroundings, so that the chemical activity of its tissues is dependent upon the *external* temperature, is called a cold-blooded animal. Since such an animal is not in reality *cold-blooded* in warm weather, a better term is *poikilothermous*, which means "changing in temperature." Conversely, an animal whose body temperature is nearly constant, remaining much higher than that of the surrounding medium even in extreme cold, is called a warm-blooded animal. Since such animals generally are provided with means of guarding against a rise of body temperature in extreme heat, a better term for them is *homoiothermous*, meaning "constant in temperature."

Among homoiothermous animals the temperature varies somewhat according to the species, thus:

Birds	39.4–43.9° C.
Cormorant	39.8–40.2° C.
Sea Gull	40.9–42.1° C.
Shag	39.4–41.4° C.
Scoter Duck	40.9–41.7° C.
Wood Duck	42.0° C.
Merganser	41.7° C.
Gannet	40.3–42.1° C.
Domestic Fowl	41.6–42.4° C.
	Simpson.
Mammals	35.5–40.5° C.
Man	37.0–37.5° C.
Monkey	37.8–39.7° C.
Horse	37.7–37.9° C.
Cow	38.6–38.9° C.
Sheep	40.0–40.6° C.
Dog	37.9–38.8° C.
Cat	38.7° C.
Rabbit	38.7–39.2° C.
Guinea Pig	37.4–39.2° C.
	Various Sources.

The Body Temperature of Man.—The temperature of an animal is usually taken in the rectum, that of man either in the mouth, axilla, or rectum. It is self-evident that the thermometer must remain in place long enough for it actually to acquire the temperature of the part if it is to record the temperature accurately; also that the temperature, as determined in these different places in the body, cannot be the same, owing to the loss of heat from the superficial parts of the body much faster than from the deeper parts. Of the places named, therefore, the temperature is highest in the rectum and lowest in the axilla. If the subject is doing physical work the temperature in the mouth may fall while the temperature in the rectum is rising. Again, after feeding a dog a large meal of carbohydrate, it has been observed that the temperature of the skin rises for a time while the temperature in the rectum may remain stationary or even show a fall. These facts indicate the necessity, always, of recording the place where the temperature is taken as well as any particular circumstances under which the subject is placed at the time.

The temperature of the surface of the body, especially of the parts habitually exposed, varies greatly, but for the clothed parts may be estimated in general at from 33° to 35° C. Le Fevre has observed that when the naked body is immersed in a bath the temperature of the surface layers is as follows:

Temperature of bath.	Temperature of skin	Temperature 2 cm. below surface of skin.	Temperature rectum 12 cm. below surface of skin.
5° C.	17.0° C.	24.0° C.	36.3° C.
18° C.	22.0° C.	24.8° C.	35.9° C.
25° C.	26.5° C.	27.1° C.	36.9° C.

The organs of the abdominal cavity are warmer than the skeletal muscles or the rectum. According to Quincke the temperature in the interior of the stomach of man is 0.12° C. higher than the rectal temperature, and, according to Ito, that of the duodenum of the rabbit is 0.7° C. higher. These temperatures may be due to the proximity of the liver, for Le Fevre has found the liver of the dog more than 1° warmer than the rectum.

Individual variations of some tenths of a degree are always found when the temperature is recorded over sufficient length of time for each individual. As a mean value 37.5° C. is usually given for the temperature of the rectum, 37.2° C. for the axilla. It is not quite correct to say that these temperatures are constant; for, neglecting variations due to disease or to excessive cooling, it is well known that, in the course of the day, the body temperature undergoes certain normal variations. In a healthy individual the temperature difference between minimum and maximum in the diurnal curve may amount to 1° to 1.5° C. In ordinary habits of life the minimum comes between three and six o'clock in the morning and the maximum between six and eight o'clock in the evening.

Cause of the Diurnal Variations of Temperature.—The cause of these variations in the body temperature lies, primarily, in the variations in the intensity of the metabolism. If the CO_2 elimination, which, to a certain extent, may be looked upon as an expression of the relative amount of metabolism, be determined at different times of day, a surprising parallelism is found between its curve and that of the

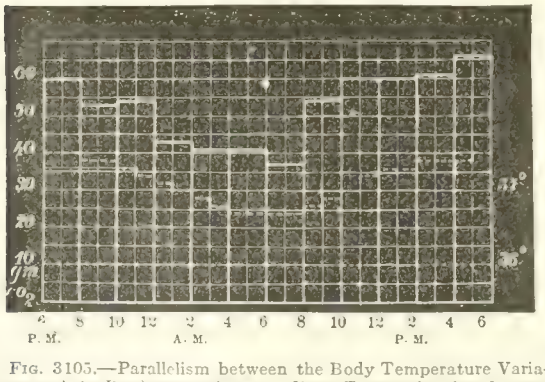

Fig. 3105.—Parallelism between the Body Temperature Variations and the Production of CO_2. (From Tigerstedt, after Jurgensen.) The continuous line indicates CO_2 per two hours; the broken lines, body temperature.

body temperature. This fact alone would be proof of the dependence of the body temperature upon the varying degrees of activity set up in the organism by the environing conditions, if there were no variation in the kind of food being oxidized during the day. No doubt if the variations in the absorption of oxygen were determined they would be found even more nearly parallel to the body temperature variations.

The factors which, it is believed, may be operative to affect the body temperature in this way are: muscular exercise, mental effort, kind and amount of food, light through its reflex effects, temperature of the surrounding medium, and sleep. Probably the first is the most important, but it requires the combined effect of all of them to account for the perfect regularity of the variations. Certain very careful observations by Mosso and F. G. Benedict indicate in fact, that there is a fixed periodicity in the body temperature which is entirely independent of any and all of these superficial circumstances. Benedict found that the minimum temperature in night workers persisted in falling in the early morning hours "independent of whether the subject was sleeping soundly in the recumbent position or was awake and sitting or even standing and walking." Among the objections which have been brought against the work of Mosso and of Benedict on night workers is the fact that an individual worker cannot be entirely disconnected from the rest of society in this way. Thus, under a reversed day and night régime, the subject necessarily works under artificial light in the stillness of the night and he must sleep in the daytime through noise and other disturbing circumstances. "The nighttime has a peculiar effect upon the general state of one's mind owing to the solitariness and various other circumstances, and this changed psychical condition reacts on all one undertakes" (Lindhard). A less objectionable method of reversing the daily routine is that of taking a journey half-way round the globe. If the body temperature were subject to a rhythmical periodicity independent of the immediate surroundings, a journey of this kind, from east to west or west to east, would completely invert the day and night with reference to the local time from which one started, and should have the effect of replacing the minimum morning temperature by the maximum evening temperature and *vice versa*. The first experiment of this kind was performed on himself by R. B. Gibson, who made a journey from New Haven, Conn. to Manila, P. I. It has since been accomplished by Osborne in a journey from Melbourne to London, and less completely, so far as the extent of the inversion was concerned, by Simpson in a journey from Ithaca, N. Y., to Edinburgh, Scotland. "Day" and "night" were reversed by Lindhard in the polar night of N. E. Greenland in the following way. Observations were made on the body temperature of all of the twenty-eight members of the expedition during the "day," *i.e.* the time during which the lamps were lighted and the men were active indoors, and again during the "night," *i.e.* when the lights were put out and the men went to bed; also upon waking. Then by postponing the bedtime four hours one day and eight hours the next and the insertion of an extra meal the "day" and "night" were reversed. In all these experiments the results were essentially the same. Complete reversal of the day and night produce a complete inversion of the diurnal temperature curve, showing that the curve is determined by work and the mode of living, and that "the astronomical division of time is without importance in this regard." Still more out of the question is any inherited form of the temperature curve or any mysterious "cosmic" influence.

Temporary changes of the body temperature in one direction or the other may be produced by various voluntary acts which tend to offset the heat production or the heat loss. Thus, the temperature falls as the result of sitting perfectly still, of drinking cold water, eating ices, etc. It rises, as a rule, as the result of exercise, taking hot drinks or food, etc. However, all such variations are, as a rule, very insignificant, and this very remarkable fact has been established—that the mean value of the temperature obtained from a large number of determinations, extending over periods of twenty-four or forty-eight hours, remains the same in spite of all such disturbances. With a free choice of food, therefore, the body measures out its supply of energy to fit the circumstances of heat loss with unerring accuracy.

Variations of temperature between persons of different age are also but slight. The fetus, having a certain small metabolism of its own and being harbored among the warmest organs of the mother's body, might be expected to have a temperature slightly higher than the mother, which, indeed, direct observations confirm. The difference, however, amounts to only 0.3° C. After birth the temperature sinks from 0.5 to 0.8° C. and continues low until near the end of the first week, a fact explained in part by bathing and in part by the time required for the process of adaptation to the new source of food. After its return to normal the temperature in health never varies far from this level. The following table, after Jundell, gives the average body temperature (rectum) for the entire twenty-four hours in persons of different age up to twenty-two years.

Age.	° C.
5 to 8 days	36.82
4 to 5 weeks	37.13
2 months....	37.12
6 months.....	37.15
2 to 5 years.	36.92
18 to 22 years	36.85

The variation amounts to only 0.33° C. For very old persons (seventy-one to ninety-eight years) the average rectal temperature, according to Chelmonski, was 36.58° C. in the morning and 36.65° in the evening.

Subjected to *excessive loss of heat* the body is unable to maintain the normal level of temperature and the disturbance to its functions is greater the lower the body temperature falls. The highest nerve centers are the first to suffer so that the person soon becomes

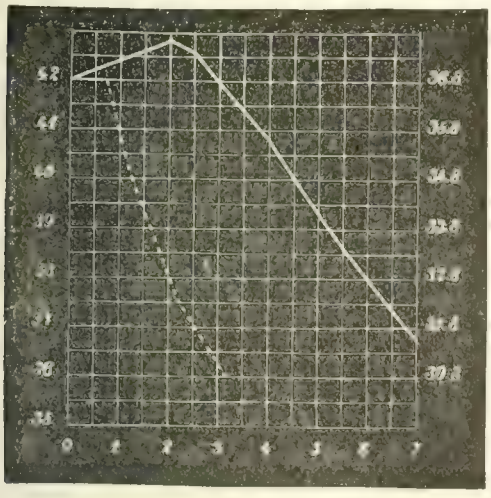

Fig. 3106.—The Course of the Body Temperature After Death. (From Tigerstedt, after Niederkorn.) The continuous line indicates death from typhoid fever, temperature at left; the broken lines, death from pulmonary consumption, temperatures at right. The abscissas denote hours after death.

unconscious. This fact explains the drowsiness of persons threatened with freezing from exposure. Life is maintained by the medullary centers, however, until the reduction of the general body temperature has gone much farther. Theoretically, restoration is possible so long as these centers (respiratory center, vasomotor center, etc.) retain their vitality. Cases have been recorded of patients who have recovered from a body temperature of 22.5° C. (Jenssen), and one case of a man who retained consciousness with a temperature of 26.7° C.

In like manner *an increase in body temperature*, if it passes a certain limit, involves first disturbances to the general health and later loss of consciousness, while the centers of the medulla remain functional. In general, it may be said that the body stands a fall better than a rise of temperature; for while, as seen above, it may recover from a fall of as much as 15° C., a rise of only 2° or 3° C. is a very serious matter, and a rise of 4° or 5° C., *i.e.* to 41° or 42° C. constitutes a very dangerous symptom. Some of the highest authenticated temperatures from which patients have recovered are: 43.6° C. in a case of syphilis of the brain (Paget); 42° C. typhoid fever (Thoma); 43.6° scarlet fever (Vincent and Bloch); 42° erysipelas (Hirz); 43.3° malaria (Mader); 43.9° acute rheumatism (Clinical Society of London).

After death the temperature of the body falls, but not always immediately. This shows that the heat production does not cease the moment the organism has taken its last breath. Besides, with the cessation of the circulation and the secretion of sweat any heat formed by postmortem phenomena in the interior of the body is not so readily lost. In cases of death from infectious diseases the temperature of the cadaver may even rise for some hours after the usual signs of life have disappeared.

The following table gives some of the higher temperatures which have been found at various intervals, in different cases, after the subjects were pronounced dead.

Temperature before death.*	Temperature after death.	Time after death.	Disease.	Author.
41.1° C.	44.5° C.	?	Heat stroke.	Levick.
44.8° C.	45.4° C.	57 min.	Lockjaw.	Wunderlich.
43.8° C.	44.2° C.	45 min.	Tuberculous meningitis.	Wunderlich.
43.2° C.	43.6° C.	15 min.	Erysipelas.	Eulenburg.
43.0° C.	44.0° C.	60 min.	Pyemia.	Quincke.
42.0° C.	43.2° C.	60 min.	Pneumonia.	Quincke.
41.1° C.	43.3° C.	15 min.	Crushing of cord.	Churchill.

The Heat Producing Organs of the Body.—Heat is produced wherever oxidation takes place in the body. Every organ and tissue, therefore, must contribute its quotum to the sum total. Some tissues, however, are in reality unimportant in this respect, notably the bones, exclusive of the marrow, the tendons, cartilage, the white matter of the nervous system and the skin. The organs and tissues which are known to be most active in the production of heat are: the cross-striated muscles, including the heart, the large glands (liver, intestine, stomach, spleen, pancreas, and kidneys) and the non-striated muscles. Taking the total heat production of a resting man of average weight (seventy kilograms) as 1,680 calories* (see below), Tigerstedt has estimated that the contribution of the different organs is as follows:

Heart	70 cal.
Muscles of respiration	150 cal.
Liver	368 cal.
Kidneys	74 cal.
Skeletal muscles	1,000 cal.
Total	1,662 cal.

This leaves only a very small fraction of the whole to be produced by the less active organs.

That the skeletal muscles must be the most impor-

* *Note.*—A calorie is the one-one-hundredth part of the heat necessary to raise one kilogram of water from 0° (freezing) to 100° (boiling) at sea level.

tant seat of heat production follows from the fact that with every muscular contraction from three-fourths to two-thirds of the energy liberated is set free as heat (see below). It has been conclusively proved, also, that heat is constantly being produced even in resting muscles. Thus, Meade-Smith determined the temperature of the vastus externus and profundus muscles of the dog simultaneously with the temperature of the blood in the aorta, with the following result:

Muscle.	Blood	Difference
38.38° C.	37.97° C.	+0.41° C.
38.41° C.	38.13° C.	+0.28° C.
38.74° C.	38.21° C.	+0.58° C.
38.28° C.	37.90° C.	+0.38° C.

It may be calculated from his observations that nearly ten calories of heat are produced in one kilogram of resting muscle in twenty-four hours.

Proof of the Sources of Animal Heat (Calorimetry).—Proof that the ultimate source of the heat produced in the animal body lies in the oxidation of its organic food stuffs dates from the time of Lavoisier, the discoverer of oxidation (1789). Lavoisier invented a calorimeter which measured the heat produced by a small animal in terms of the number of grams of ice melted. By means of another apparatus which was never described fully (the inventor's notes having been destroyed in the French Revolution, during which he was beheaded after having unavailingly begged for a prolongation of life for two weeks in order to complete certain experiments), Lavoisier learned not only that oxidation is the source of heat in the human body, but that the amount of heat so produced is greater during muscular work, after tak-

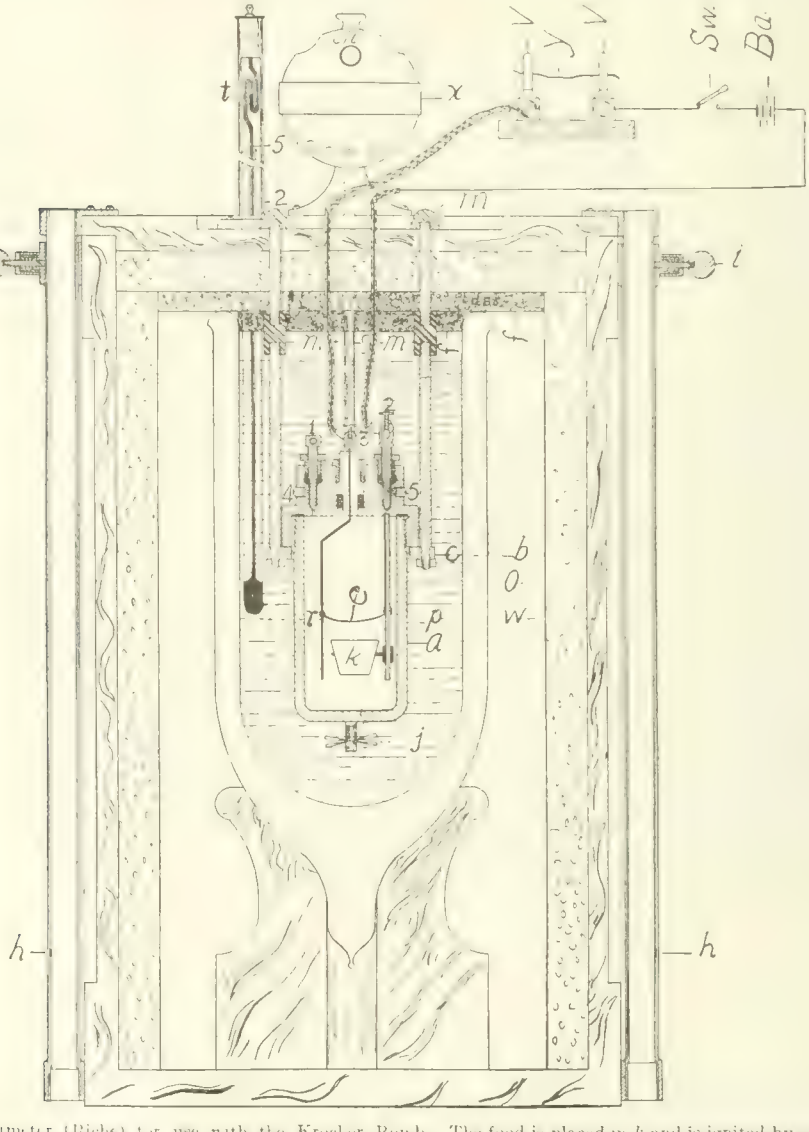

Fig. 3107.—Calorimeter (Riche) for use with the Krocker Bomb. The food is placed in *k* and is ignited by sending a known amount of current through *e*. *a*, Bomb; *b*, vacuum cup; *c*, split ring; *e*, platinum wire; *f*, felt; *h*, hole in inner tube; *i*, spring stops; *j*, stirrer; *k*, capsule; *m*, fibre; *o*, cork; *p*, platinum tube; *r*, platinum rod; *s*, stirrer rod; *t*, thermometer; *v*, fuse wire posts; *w*, wooden box; *x*, motor; *y*, fuse wire; *Sw*, switch; *Ba*, storage batteries; 1, valve screw; 2, valve screw; 3, insulated post; 4, inlet screw; 5, inlet screw. (Journal of the American Chemical Society.)

ing food and greater at a low than at a high external temperature.

Lavoisier, however, assumed that the heat value of a compound was equal to the sum of the combustion heat values of its constituent elements. Thus, according to his ideas, the heat value of formic acid (CO_2H_2) should be equal to the combustion heat values of H and O. This, however, is not the case; for the heat value of $2H(2H+O=H_2O)$ is 683 cal., per gram. mol., and of $C(C+O_2=CO_2)$ is 943 cal., whereas the heat values of $CO_2H_2(CO_2H_2+O=CO_2+H_2O)$ is only 694 cal. The difference between the combustion heat value of CO_2H_2 and the sum of the heat values of H_2 and C is known as the heat of formation (*Bildungswärme*). That is, it is the heat developed and set free when the elements were combined to form the compound.

All food stuffs are organic compounds of this sort, but most of them are much more complex in their structure than formic acid. The combustion heat value of a substance is determined by burning it in an atmosphere of pure oxygen, in an apparatus known as a bomb calorimeter, of which there are many different forms. One of the most recent forms is shown in Fig. 3107.

The subjoined table gives the combustion heat value of some of the most important food stuffs:

HEAT VALUE OF ONE GRAM OF EACH SUBSTANCE

Substance.	Stohmann.	Berthelot	Rubner.	Benedict.
Glycerin	4.316			4.323
Glucose	3.743	3.762		3 739
Levulose	3.755			3.729
Galactose	3.722			
Cane sugar	3.955	3.962	4.001	
Milk sugar	3.737	3.777		3.737
Maltose	3.722			3.776
Dextrin		4.119		
Starch	4.183	4.228		
Palmitic acid		9.265–9.369	9.745	9 318
Stearic acid		9.429–9.549	9.745	9 499
Oleic acid		9.511	9.334	9 423
Animal fat	9.500			
Butter	9.231			
Vegetable oil		9.520		
White of egg	5.735	5.687		
Yolk of egg	5.841			
Beef (ext. free of fat).	5.721	5.728	5 778	
Veal	5.663			
Casein	5.850	5.626		
Peptone from fibrin.	5.942			
Glycogen				4 227
Alanine				4.401
Asparagin				3 065
Aspartic acid				2.882
Creatine				4.240
Creatinine				4.988
Cystin				4.137
Glutamic acid				3.662
Glycocoll				3.110
Tyrosine				5.915
Alcohol				7 104
Lactic acid				3.615

If the end-products of oxidation were exactly the same in the body as in the calorimeter, the amount of heat produced by these substances when they are oxidized in the body should be the same as when they are burned in pure oxygen. This, in fact, is the case normally with all the pure carbohydrates and fats; for the end-products of oxidation in both instances are only CO_2 and H_2O. With the nitrogenous foods (proteins, extractives) the physiological heat value should be less than the calorimetric heat value for the reason that the body does not oxidize nitrogen completely. If it should do so, the end-product (nitric acid) would be very harmful to the body and would require to be neutralized in some way. Those products which represent the partially oxidized nitrogen of the proteins of the food are excreted in solution in the urine (urea, uric acid, etc.). Hence the physiological heat value of any protein (*e.g.* washed meat) may be found by subtracting the combustion heat value of its nitrogenous waste products from the combustion heat value of the meat itself. To make the determination still more exact, it is necessary to make certain other corrections. Thus, while meat or casein, for example, may be completely digested and absorbed, they always occasion a loss of nitrogenous material from the bowel, which represents the unabsorbed residues of the digestive juices. The heat value of the feces, therefore, should be subtracted. Then there are certain small heat fractions lost in the imbibition of water by the protein and in the solution of the urea, etc., in the urine. Making all these corrections for lean meat, extracted free of fat and dried, Rubner obtained the following from a feeding experiment with a dog.

		Calories.
100 grams fat-free, dried meat, combustion		535.5
Urine	112.9 cal.	
Feces	16.8 cal.	
Imbibition of water	2.7 cal.	
Heat of solution	2.0 cal.	
	134.4 cal.	134.4
Difference		400.1

The heat value to the dog's body, therefore, was 4.0 calories per gram. Rubner had previously determined the dynamic equivalents of the different food stuffs in terms of each other; thus: 100 grams fat are equal in heat value to 211 grams of protein, 232 grams of starch or 234 grams of cane sugar. Later he published the following as the physiological heat values of the three principal food stuffs:

1 gram protein	4.1 calories.
1 gram starch or sugar	4.1 calories
1 gram fat	9.3 calories

Indirect Calorimetry.—With the correct determination of the calorimetric heat values of the simpler food stuffs, it became possible to determine the total heat production of the human body. Pettenkoffer and Voit, under the patronage of the King of Bavaria, constructed in Munich in 1860, a respiration apparatus which enabled them to estimate the products of respiration from an adult man in twenty-four-hour periods. By collecting all the other excreta, they then were able to compute the total loss of the different elements from the body. Knowing the total nitrogen elimination from the body, by multiplying this amount by 6.25 they obtained the amount of protein used up. From the total amount of carbon eliminated they were able to calculate the amount of the non-nitrogenous materials consumed. Knowing that proteins contain 3.28 times as much carbon as nitrogen one deducts first the quantity of carbon belonging to protein. If no food has been ingested during the time of the experiment, nor for twenty-four hours before, it is assumed that all the rest of the carbon came from fat.* Dividing the remainder of the carbon by 0.76, the percentage of carbon in fat, one obtains the number of grams of fat. If food is taken, containing only protein, or only fat or only protein and fat, the same calculation suffices to give the total amount of each food stuff oxidized. Should the food contain carbohydrate, it is necessary to know the number of grams of carbohydrate absorbed. Since it is known that carbohydrate is oxidized in the body more readily than fat, it is assumed that all of this carbohydrate

*Note.—It is now known that this is not strictly correct, for even as much as eight days of fasting does not exhaust all the glycogen stored in the tissues.

absorbed would be oxidized before any fat is drawn upon. Deducting from the total carbon excreted, first the carbon of protein, then the carbon belonging to the amount of carbohydrate absorbed, what remains is again counted as carbon of fat. In this way Pettenkofer and Voit computed the amounts of the different food stuffs destroyed in the body under different conditions. But it was not until Rubner had perfected his method of determining the heat values of the food stuffs about 1885, that it became possible to compute the total heat production. Taking the figures which Pettenkoffer and Voit had found from a fasting man, namely, 70.8 grams protein and 222 grams fat as the amount destroyed in twenty-four hours, Rubner multiplied these amounts by the physiological heat values of protein and fat respectively, and learned that the man, while fasting, had produced in his body 2355.8 calories of heat energy in twenty-four hours, or about thirty-three calories per kilogram of net body weight. This method of computing the heat production is known as the method of *indirect calorimetry*.

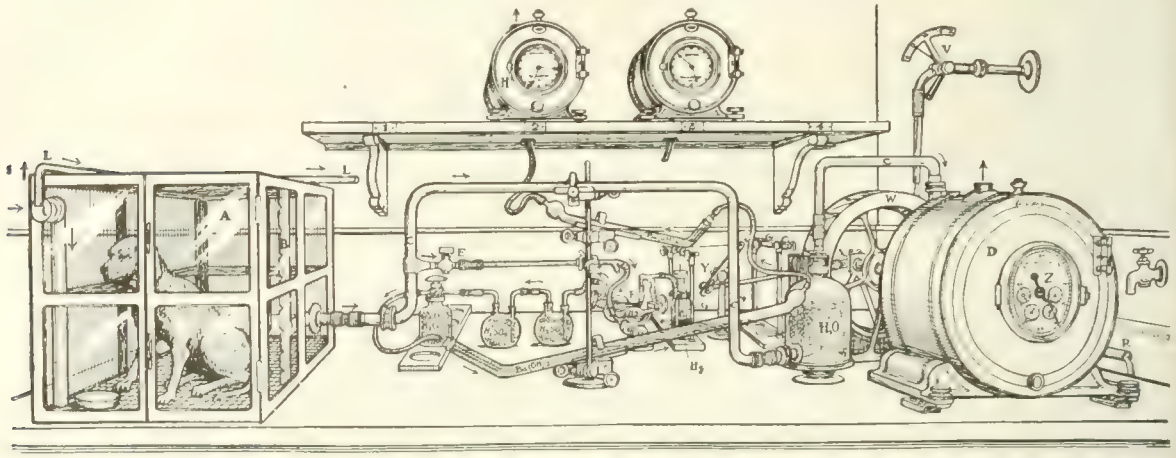

FIG. 3108.—The smaller respiration apparatus of Pettenkoffer and Voit. Air enters the cage, A, at the upper left-hand corner. It is drawn out through openings in the tube *B* (so spaced as to insure thorough diffusion) through the tube, *C*, and the large H_2O flask, where it is saturated with moisture, to the gas meter, *D*, where it is measured. The meter is driven by a water wheel, *W*, rotated at a uniform rate of speed by a constant head of water pressure, *V*. At *E* a side tube leads off from *C* conveying a sample of cage air for analysis. This air is drawn through a mercury valve, *F*, by means of the mercury pump, *G*. The latter is operated by the mechanism, *X*, *Y*, connected with the water wheel. From the valve, *F*, this air passes through two H_2SO_2 flasks and is then saturated with moisture so as to prevent loss of water from the $Ba(OH)_2$ tubes. Of course the air as it leaves the $Ba(OH)_2$ tubes, is saturated with moisture, and is measured by the small gas meter, *H*, just as in the case of the large meter, while in this saturated condition. A duplicate sample is led off at the same time through another branch of the tube, *E*, and through another system of vessels to the gas meter at 3. Through the branches of the tube, *L*, duplicate samples of the air which enters the cage are drawn in the same manner to similar valves, and then through similar vessels and tubes to meters placed at 1 and 4. (From Tigerstedt, New York, D. Appleton & Co.)

The amount of oxygen necessary for the oxidation of the indicated quantities of the food stuffs consumed can readily be calculated from the known average composition of the protein, fats and carbohydrates. The only method of checking this result, however, in the procedure of Pettenkoffer and Voit, consists in subtracting from the final weight of the subject plus the weight of the excreta, the original weight of the subject plus the weight of the ingesta. The difference should equal the weight of the oxygen absorbed and united with the combustible compounds. While this method of estimating the oxygen absorption of the subject is not very exact, it enabled Pettenkoffer and Voit to learn positively that very little, if any, carbohydrate was oxidized in the body of their fasting subject.

This they knew from the *respiratory quotient*. This term is applied to the quotient expressing the relationship between the volume of carbon dioxide eliminated by the breath and the oxygen absorbed therefrom. The value of this quotient $\frac{CO_2}{O_2}$ varies with the kind of food stuff being burned, because the amount of oxygen already present in the compound is different. With carbohydrate the H and O are present in the proper proportion to form water (*e.g.* $C_6H_{12}O_6$). Oxygen is required, therefore, only to satisfy the combining power of carbon. Hence, the R. Q. would be equal to unity. Thus: $C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$. The number of molecules of O_2 absorbed in this reaction being equal to the number of molecules of CO_2 produced, the R. Q. would be 1. Fats and proteins contain relatively more C and less O than do carbohydrates. Hence, relatively more O is required for their combustion, whether in the body or in the calorimeter. The average value for fats is commonly given as 0.71 and for proteins 0.78. In the case of their fasting individual Pettenkoffer and Voit found a R. Q. of 0.69, which indicated clearly enough that nothing with an oxygen content as high as that of carbohydrate could have taken much part in the oxidation. The R. Q. of a man on an average mixed diet is in the neighborhood of 0.8.

Direct methods for the determination of the oxygen absorbed are now in use. The method devised by F. G. Benedict consists essentially in the maintenance of a constant tension inside the respiration chamber, by admission of oxygen from a cylinder, to replace the oxygen used up by the subject. In this form of apparatus the same air is circulated round and round through the respiration chamber and the absorbers for the removal of carbon dioxide and water. If the system contains at the end of an experimental period the same quantity of residual CO_2 and H_2O as at the beginning and oxygen is admitted until the atmosphere contained in the system has the same tension as at the beginning, then the loss in weight of the oxygen cylinder gives the weight of oxygen consumed by the subject.

Knowledge of the oxygen absorbed makes it possible

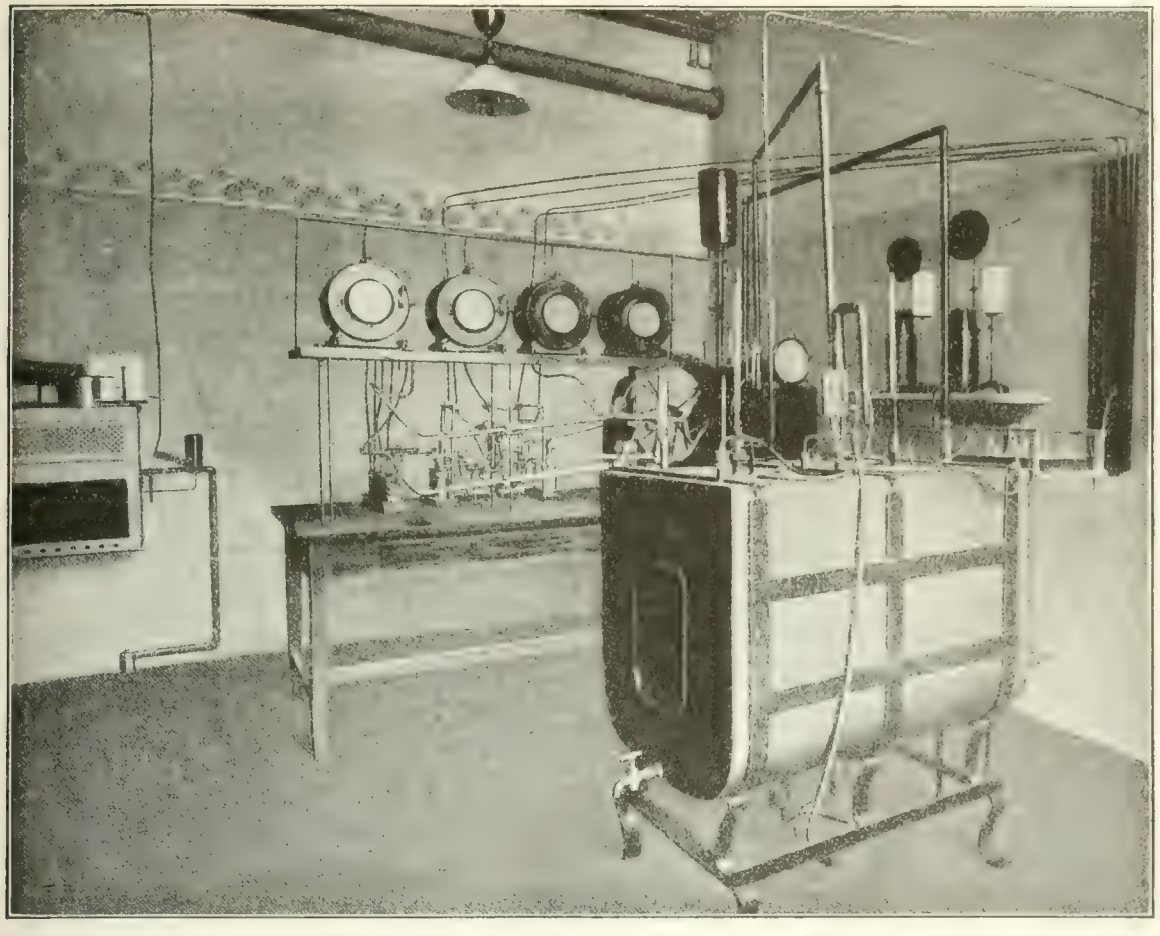

FIG. 3109.—Rubner's original animal calorimeter showing means of ventilation.

to determine the amounts of the different food stuffs oxidized more accurately than by the method of Pettenkoffer and Voit. The method of Zuntz Schumberg is as follows:

All calculations on the basis of one hour.

The N in the urine (per hour) (a) $\times 2.56 =$ C from protein in the respiration.

The CO_2 output in grams per hour $\times \frac{3}{11} =$ C output in grams per hour.

The C of respiration $-$ C of protein in respiration $=$ C of carbohydrate and fat in respiration (b).

N in urine $\times 8.45 =$ O from protein in respiration

Total O absorbed $-$ O from protein $=$ O absorbed for carbohydrate and fat (c).

The O for oxidation of one gram of fat $= 3.751$ (average).

The O for oxidation of one gram of CH $= 2.651$ (average).

Let x = number of grams C from fat (1 gm. C from fat $= 12.3$ cal.).

Let y = number of grams C from CH (1 gm. C from CH $= 9.5$ cal.).

$x + y = b$. (1 gm. N from Prot. $= 26.0$ cal.).

$3.751x + 2.651y = c$.

Solving for x and y

$a \times 26$ = cal. from prot.
$y \times 12.3$ = cal. from fat
$y \times 9.5$ = cal. from CH
Total = cal. per hour.

Direct Calorimetry.—The first to attempt a comparison of the heat production as calculated from the excretory products with the heat production as directly measured was Rubner in 1891. In his laboratory at Marburg he constructed a calorimeter consisting of a closed cage large enough to contain a large dog, and immersed it in a large copper water bath—all but the opening left for access to the cage. The calorimeter was ventilated on the same principle as the Voit-Pettenkoffer respiration apparatus, the temperature of the entering and issuing air being carefully recorded. The volume of the water surrounding the cage being known, the heat given off by the dog—all but the small quantity conveyed away by the air current—was measured by the rise in temperature of this water.

The results of Rubner's experiments reported in 1894 are as follows:

No.	Animal	Food per day.	No. days.	Heat prod. calculated.	Heat prod. measured.	Difference in per cent.
1	Dog I	Fasting	5	1,296.3	1,305.2	+0.69
2	Dog II	Fasting.	2	1,091.2	1,056.6	−3.15
3	Dog I	390 gm. meat	1	329.9	333.9	+1.20
4	Dog I	40 gm. lard	5	1,510.1	1,495.3	−0.97
5	Dog I	80 gm. meat 30 gm. lard	12	3,985.4	3,958.4	−0.68
6	Dog I	Same	8	2,492.4	2,488.0	−0.17
7	Dog I	350 gm. meat	6	2,249.8	2,276.9	+1.20
8	Dog II	580 gm. meat	7	4,780.8	4,769.3	−0.24
			46	17,735.9	17,683.6	−0.30

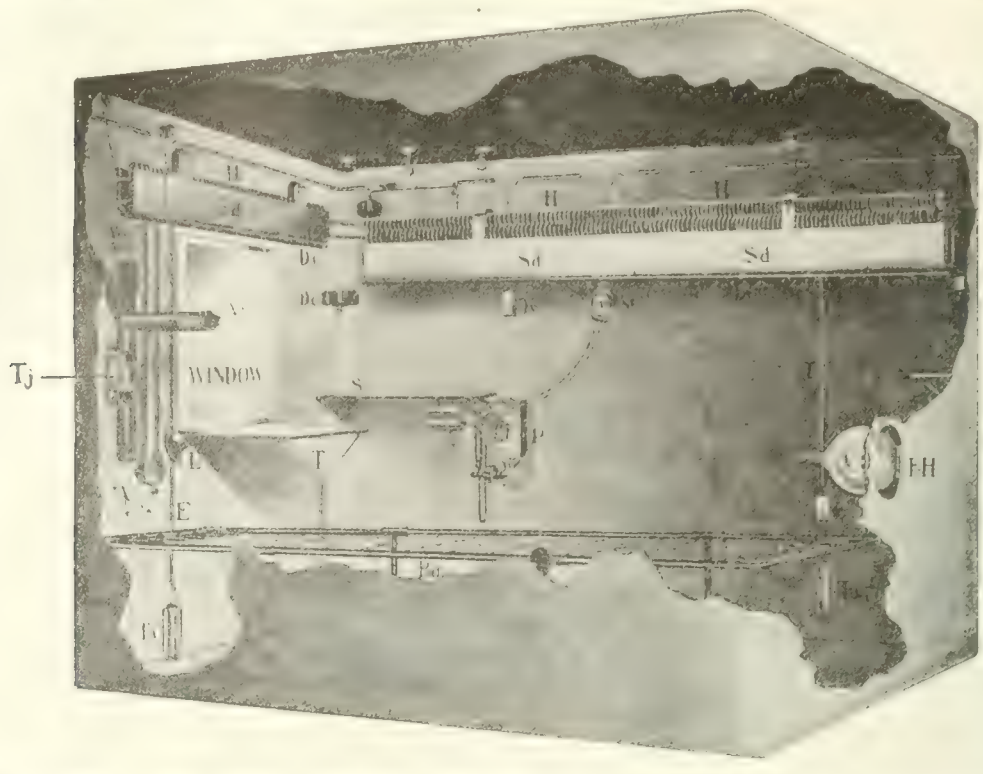

FIG. 3110.—Section of copper chamber, showing absorption system for collection of heat (*H*), by 1 (*H*), air inlet (*A*) and outlet (*A*), etc. (Atwater and Rosa.)

In a total of forty-six days of experimentation, with his animals on various kinds of food, Rubner thus found a difference of only 0.3 per cent. between the heat production, as calculated, and the heat production as directly measured. This proves, conclusively, the correctness of the physiological heat values assigned by Rubner to the three classes of food stuffs and proves also that the energy set free in their oxidation (when the animal is doing no external work), whatever transformations it may undergo in the body, finally leaves the body as heat. In other words, all the available energy which entered the body in potential form had been recovered as heat, and the applicability of the law of the conservation of energy to the animal body was thus demonstrated.

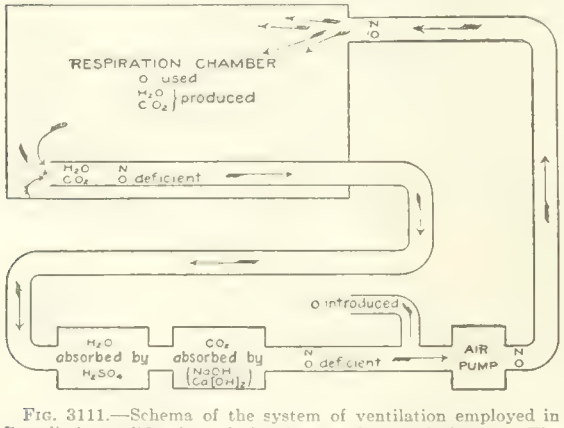

FIG. 3111.—Schema of the system of ventilation employed in Benedict's modification of the Atwater-Rosa calorimeter. The respiration chamber is the inner chamber of the calorimeter.

In 1892 Atwater and Rosa, in this country, began the construction of a calorimeter at the Wesleyan University, Middletown, Conn., which, it was planned, should measure, directly, the heat production of a man. The first results were published in 1897 in a Bulletin of the U. S. Dept. of Agriculture, which had extended financial assistance, and subsequent results in numerous Bulletins published since.

The principle of this apparatus, so far as its heat-measuring features were concerned, was different from that of Rubner. The chamber (2.15 meters long × 1.22 meters wide × 1.92 meters high) was built of copper and was placed inside a succession of walls, consisting of zinc and wood, enclosing dead air spaces. Between the copper and zinc walls were placed thermo-electric junctions so that at any moment it could be determined whether heat was leaving the chamber or entering it through the walls. Outside the zinc walls were placed cooling tubes carrying a stream of water of suitable temperature and wires which could be heated by passing through them a current of electricity. The space immediately adjoining the copper wall could, therefore, be cooled or warmed as required to keep the inner space next the copper wall adiabatic. With no heat leaving or entering the chamber through the wall and with the air leaving and entering properly recorded, the bulk of the heat produced by the subject was absorbed by a stream of cool water circulated through a series of copper pipes in the upper part of the chamber. The temperature of this water as it entered and left the chamber was recorded every two minutes by a person who also controlled, through electric appliances, the condition of the walls. The amount of water passing through in a given time was determined by weighing. The number of calories of heat carried away was,

therefore, found by multiplying the number of kilograms of water which had circulated by the average difference in temperature noted between the entering and leaving water.

The most important results obtained by means of this apparatus were: (1) the confirmation for the human body of the observations made by Rubner on the dog; and (2) the influence of muscular work on the heat production. The agreement between the heat production as calculated and the heat production as measured was very close. Thus, as a mean of seventy-six days of experimentation of nineteen different subjects, the discrepancy was only 0.3 per cent.—exactly the same as in Rubner's experiments. Some of these subjects were required to do muscular work on a stationary bicycle set up inside the respiration chamber. By suitable friction appliances the mechanical motion imparted to this ergometer was converted back to heat, and was measured as such, together with the free heat conducted directly from the subject's body. The heat as calculated from the excretory products, under these circumstances, again bore a very close agreement with the total heat as directly measured. Incidentally, it was found that alcohol might serve as a source of energy for muscular work up to about three ounces per day.

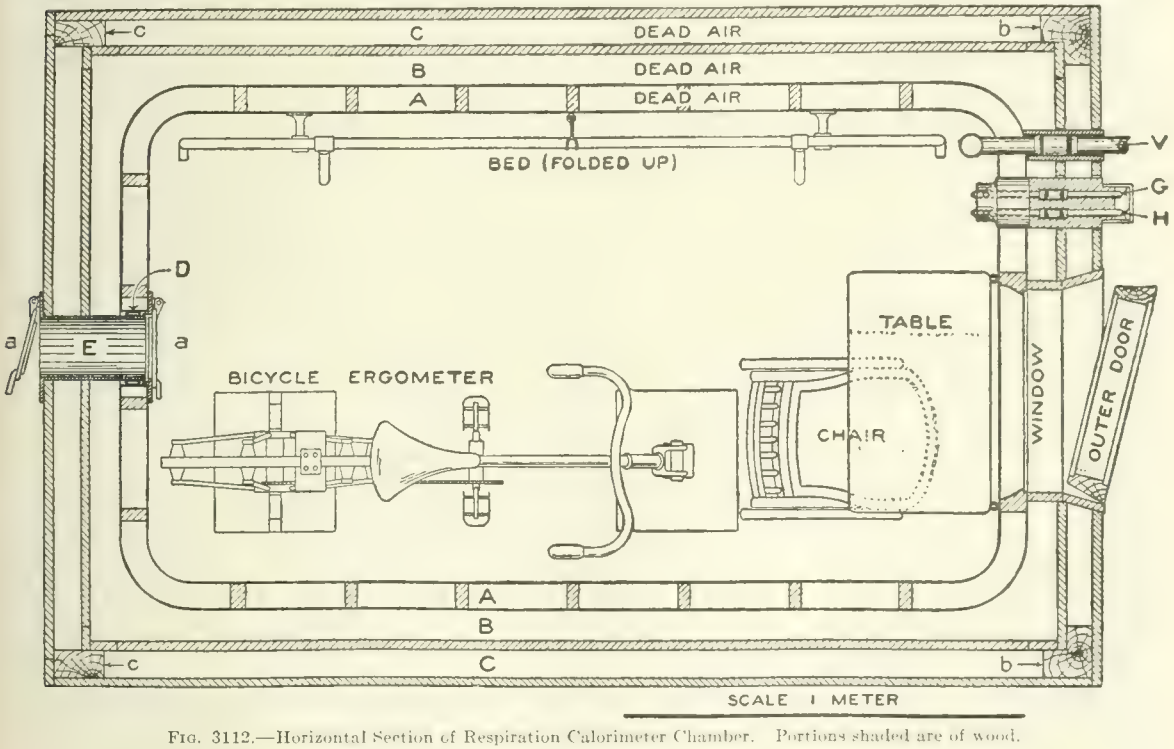

Fig. 3112.—Horizontal Section of Respiration Calorimeter Chamber. Portions shaded are of wood.

Influence of Muscular Work on the Heat Production.—When Liebig had completed his classification of the food stuffs, and had found that all animal tissues contain proteins, *i.e.* are nitrogenous, he suggested that the excretion of nitrogen by the animal might be used as a measure of protein destruction in the animal's body. Carl Voit, who had been a pupil of Liebig was the first to put this suggestion to practical use. Among many other important facts regarding the metabolism of proteins Voit discovered that, contrary to the teaching of Liebig, the protein of the body is not the source of the muscular energy; for, during muscular work, no more nitrogen is eliminated than in muscular rest. Since it had been known from the time of Lavoisier that muscular exercise increased the heat production, it followed, from the observations of Voit, that the non-nitrogenous food stuffs must be the source of the extra heat production as well as for the energy of muscular contraction. This fact is now thoroughly established by almost numberless experiments. An illustration may be taken from the work of Atwater cited above. A subject doing work on the bicycle ergometer produced in twenty-four hours 5,100 calories of heat, of which 434 calories came from protein ($N \times 6.25 \times 4.1$). In muscular rest this same individual produced only 2,270 calories of which 400 came from protein. The day's work had increased the total heat production 2,830 calories, but the heat from protein had been increased only thirty-four calories. All of the rest, 2,800 calories (nearly), came from non-nitrogenous food.

A matter of great interest among physiologists has been the question of the amount of potential food energy which can be converted into mechanical work by the animal body. Engineers find that it is an exceptional locomotive which can convert as much as fifteen per cent. of the heat energy of fuel into mechanical work. The remaining eighty-five per cent. is waste heat. The first to attack this question seriously for the animal body was N. Zuntz in Berlin. Collecting the respiratory products of combustion by means of a face mask he studied the effect upon the heat production (as calculated) in man of walking on the level, and of climbing a mountain; in the dog and horse of working a treadmill which could be placed at any desired grade, etc. As the result of these experiments he found equally for the man, horse, and dog that one kilogram meter of work (lifting one kilogram of body weight one meter high) required the expenditure of 0.0069–0.0072 calories of energy. Since the theoretical heat equivalent of one kilogram of work is 0.0023 calories, it follows that about

three calories of heat energy must be set free in the animal body to do one calorie's worth of work. The mechanical efficiency, in other words, is about thirty-three per cent. (compared with fifteen per cent. for the locomotive). Heinemann has found similar results for work with the legs and an efficiency of 22.6 per cent. for work with the arms. Atwater's results with the bicycle ergometer gave a mechanical efficiency for the legs (and arms) of only thirteen to nineteen per cent.

Influence of External Temperature on Heat Production in Warm-blooded Animals.—It has been noted above that the influence of external temperature on the heat production of cold-blooded animals, as in plants, follows Van't Hoff's law. In warm-blooded animals, however, with the development of the capacity to regulate the body temperature independently of the surrounding medium, this law is to some extent reversed, so that the lower the external temperature becomes the greater is the heat production. This is necessarily the case if the body temperature is to be maintained. Confirming the original observation of Lavoisier that more heat is produced in the human subject when the external temperature is low, C. Voit exposed a naked man in his respiration apparatus to different temperatures and found that, as the temperature fell, the metabolism increased independently of any muscular motions. Rubner carried this line of investigation much farther, using dogs and guinea-pigs, and formulated his laws of the chemical and physical regulation of the body temperature. In brief, these laws are: (1) That, from a temperature of about 30° C. downward, the body temperature is regulated chiefly by varying the heat production (chemical regulation). Heat loss is regulated, to some extent, by decreasing the amount of blood brought to the surface. (2) From 30° C. upward the body temperature is regulated chiefly by varying the amount of water evaporated from the surface (sweating) and again by increasing the amount of blood brought to the surface (physical regulation).

How Heat is Lost from the Body.—In general, there are four main avenues of escape for the heat which is produced in the body of a warm-blooded animal: (1) Warming the food and air which enter the body; (2) Vaporization of water and setting free CO_2 in the lungs. (3) Evaporation of water from the surface of the body; (4) Radiation and conduction from surface of the body.

Rubner has made the following calculations for a man producing 2,700 calories daily:

	Calories
(1) Warming food and drink to body temperature.	42
(2) Warming air from 17.5° to 30° C.	35
(3) Evaporation of water from lungs and skin.	558
(4) Heat equivalent of external work done.	51
(5) Loss of radiation from entire surface of body	1,181
(6) Loss by conduction to air from entire surface	833
Total	2,700

Atwater, in his calorimetric studies, made the following estimations:

I. Resting man, mean of fourteen experiments comprising forty-two days:

	Calories.
1. Heat loss by radiation and conduction.	1,683
2. Heat loss by urine and feces.	31
3. Heat loss by evaporation from lungs and skin.	548
Total	2,262

II. Man at work, mean of twenty experiments comprising sixty-six days:

	Calories.
1. Heat loss by radiation and conduction.	3,340
2. Heat loss by urine and feces.	26
3. Heat loss by evaporation from lungs and skin.	859
4. Heat equivalent of muscular work.	451
Total	4,676

It is evident, from these estimates, that fully eighty per cent. of all the heat produced in the body is lost through the skin.

Rubner's Law of Surface Area.—Closely related to this matter of the loss of heat through the skin is the fact, discovered by Rubner, that, in animals of different size, the total heat production is proportional, not to the body weight, but to the amount of skin surface exposed to the air. A small animal has a greater surface, in proportion to its weight, than has a large animal. This will be clear from the following illustration. Suppose we have two spheres of two and four centimeters diameter. The surface of the smaller would be 12.56 square centimeters and of the larger 50.24 square centimeters. The volume of the first would be 4.18 c.c. and of the latter 33.49 c.c. The surface of the smaller, in proportion to its volume, therefore, would be as 3 : 1, while of the larger it would be only as 1.5 : 1. Since, now, more than four-fifths of the animal's heat escapes through the skin, it is clear that heat must be produced in proportion to the surface rather than in proportion to the mass, if the body temperature is to be maintained. Hence, if two animals, with similar coats of fur, had skin surfaces that bore to each other the relation of these spheres, the smaller animal would produce twice as much heat per unit of weight as the larger. Rubner found that the average heat production per square meter of body surface for man, dog, rabbit, guinea-pig, and mouse was 1,088 calories with variations of −104 calories to +103 calories, *i.e.* of about ten per cent. either way. Rubner claims, indeed, that this law is, to some extent, independent of the loss of heat through the skin; for it holds good for guinea pigs of different size even when subjected to a temperature at which there is practically no loss of heat through the skin. Jolyet and Regnard have found that the law of heat production in proportion to skin surface applies also to cold-blooded animals where there is no internal regulation of the body temperature. Rubner's explanation of these facts is that, under conditions, where the requirement for energy is minimal (30° C.), the work of the organs of respiration, circulation, etc., must be adapted to the requirements which may be placed upon them at any moment through the operation of the chemical regulation; *i.e.* the stimulation through cold acting upon the skin. v. Hoesslin goes still further, asserting that, in the struggle for existence, all animals, in striving to develop their utmost power compatible with their body size, must, inevitably, reach about the same metabolism per unit of body surface. The advantage of one animal over the other, therefore, would lie in the anatomical peculiarities which enable one to convert more energy into external work than another.

Protection against Heat Loss.—Practically all warm-blooded animals have some means of protection against excessive heat loss. The most important of these are the natural coverings (hair, fur, feathers) on the skin and subcutaneous fat. The chief value of hair, fur, etc., in this connection lies in the large quantity of stagnant air which they occlude. This air, being stagnant, retards the conduction of heat away from the body. Subcutaneous fat, on the other hand, is a poor conductor of heat, a layer only two millimeters thick having been found to diminish the heat loss in a unit of time more than fifty per cent. Subcutaneous fat is especially important for aquatic mammals, because the water wets the fur driving out all the air.

The human body, not being provided with a complete natural coat of hair, requires the aid of artificial coverings in order to maintain its temperature in climates which average less than 27 or 28° C. Above this temperature, the naked body is able to regulate its temperature unaided. Clothes serve to diminish the movement of warm air away from the body in

the same way as hair, fur, and feathers do. It has been estimated that no less than ten liters of air may be occluded by the meshes of a woolen suit of clothes, and some ten to twenty liters more may be held in the spaces between different garments and between the garments and the body. Heat loss by radiation is also reduced by clothes, the exact effect depending on the conductivity of the material.

Regulation of the Body Temperature.—It has been noted above (page 110) that the body temperature varies between very narrow limits. This fact, in itself, is a proof that the mechanism of heat production is very nicely adjusted to the process of heat loss. How is this cooperation brought about? It has been shown that, when a man is subjected to an external temperature (bath) varying slowly between 34° and 37° C., the mechanism of heat loss (sweating) is brought into play when the body temperature (rectum) has risen on the average 0.34°, and the mechanism of heat production (shivering) when the body temperature has fallen on the average 0.26°. Likewise, in muscular work, sweat breaks out when the body temperature has risen on the average 0.43°. Whether the reaction in each case is brought about by the change in temperature of the blood and a direct stimulation of the sweat centers, or the motor centers respectively or by reflex stimulation of these centers through the cutaneous nerves, is not definitely known. There is much evidence that the corpora striata in the base of the fore-brain contain a center which is particularly susceptible to changes in temperature and to mechanical stimulation.

Influence of Food on the Heat Production.—The observation of Lavoisier that the heat production was increased by taking food was confirmed by Pettenkoffer and Voit, who found that the total metabolism of a dog was increased from 34.9 to sixty-five calories per kilogram as the result of eating about two and one-half pounds of meat. Feeding fat they observed no increase in the heat production unless the amount fed was far in excess of the body requirement. Feeding carbohydrate in the form of starch they found that 379 grams in the food increased the metabolism seventeen per cent. over that of the starving animal. More exact information concerning the influence of carbohydrate came with the invention of methods by Zuntz and by Benedict by which the oxygen absorption could be determined, since, without this knowledge, it was impossible to distinguish the part taken by fat in the total heat production from that taken by

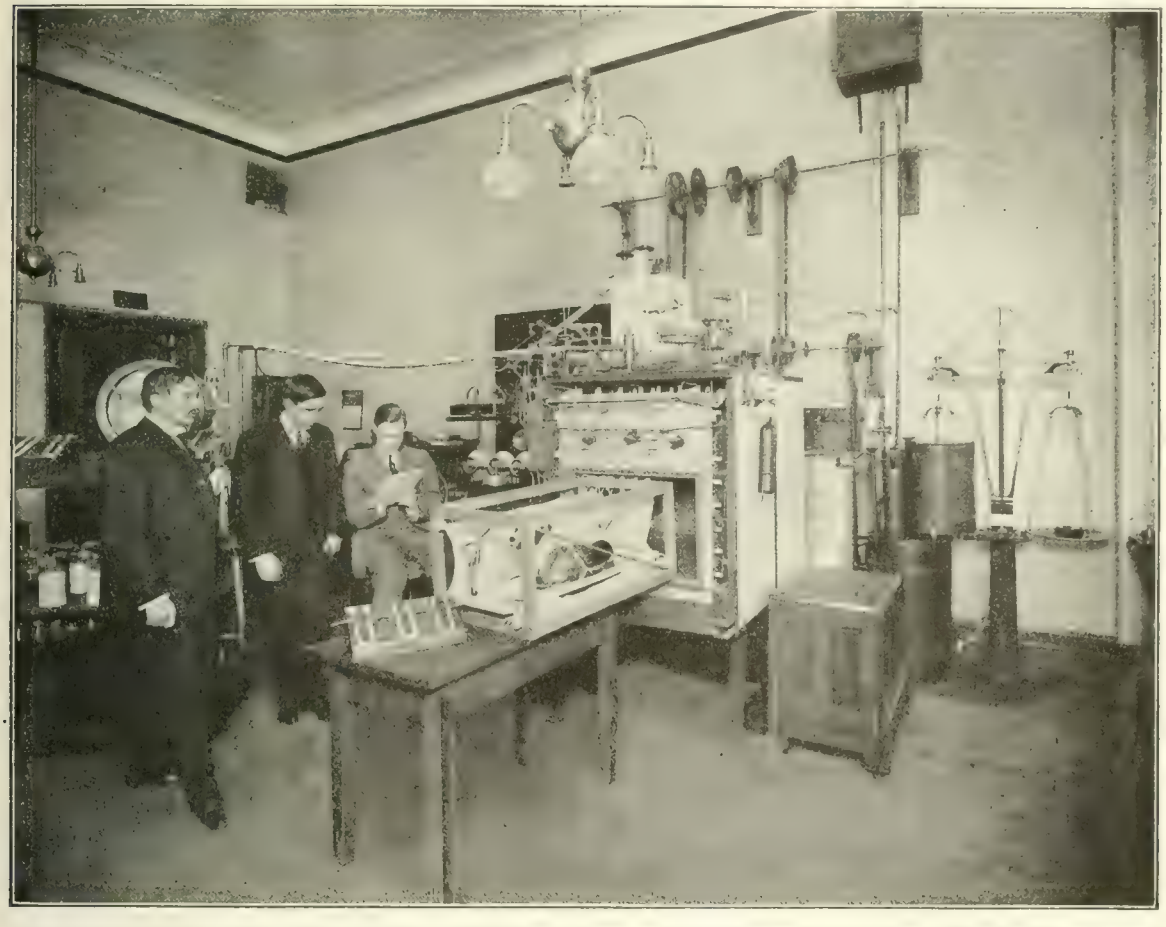

Fig. 3113.—Showing a Respiration Calorimeter Built for Observations on the Dog, at Cornell University Medical College, New York City. The dog, wearing a bandage which holds a rectal thermometer in place, is shown lying on a cot suspended from a frame which may at any time be slid into the open chamber of the calorimeter. This accomplished the front is then sealed. The animal respires within the chamber, the water and carbonic acid which he eliminates are removed by circulating the air through absorbing chemicals, and fresh oxygen is admitted automatically to replace the oxygen absorbed by the animal. Four people are constantly employed during the experiment. The heat produced by the dog is removed and measured by a current of water flowing through a system of pipes within the calorimeter. (From the Medical Record.)

carbohydrate. Magnus-Levy, using the Zuntz method with human subjects, came to the conclusion, substantially in accord with those of Pettenkoffer and Voit, namely, that moderate quantities of fat do not increase the heat production (absorption of oxygen) but that both carbohydrate and fat increase it considerably. Rubner, using only the excretion of CO_2 as the measure of heat production, formulated laws regarding the influence of different foods given to dogs, as follows: Since the different food stuffs affect the heat production to a different degree, we may speak of their "specific dynamic action." The proper basis of comparison is the amount of heat produced by the fasting animal. Taking this quantity as the minimal requirement of the animal for energy (in potential form), and feeding this quantity in the form of the different food stuffs, the effect is for protein an increase of heat production of 30 per cent., for fat 11 per cent., for carbohydrates 5.8 per

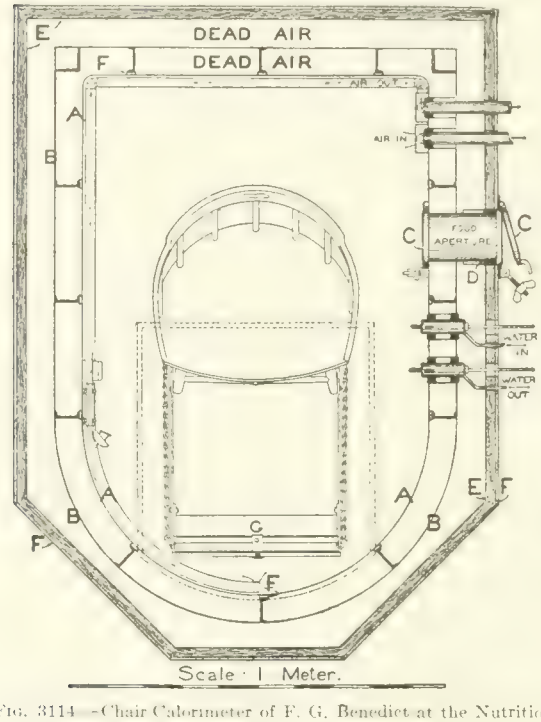

Fig. 3114.—Chair Calorimeter of F. G. Benedict at the Nutrition Laboratory of the Carnegie Institution, Boston, Mass.

cent. In order to keep the animal in an energy equilibrium, therefore, it is necessary to feed him in protein 140 per cent. of the requirement, in fat 114 per cent., and in carbohydrate 106 per cent.

The most recent contribution to the subject of the specific dynamic action of foods has been made by Graham Lusk and his coworkers, using a small respiration calorimeter of the Atwater-Rosa-Benedict type suitable for studies on dogs, babies, and dwarfs. Lusk finds that the heat production of the dog is greatly increased by certain amino-acids which are constituent parts of the protein molecule into which it is split up in digestion. These chemical bodies, when absorbed and carried by the circulation to the heat-producing organs, stimulate the latter to greater oxidative activity, causing, therefore, a greater absorption of oxygen and a greater production of heat. Carbohydrate and fat, on the other hand, increase the metabolism by a sort of mass action, *i.e.* more burns just because there is more available to oxidation. Of the three food stuffs fat seems to increase the heat production least. The greatest heat production with protein comes at about the fourth hour after ingestion and is parallel with the excretion of nitrogen in the urine.

Heat Production under Abnormal Conditions.—The calorimeter promises great usefulness in determining some of the fundamental alterations produced by disease. F. G. Benedict, at the Nutrition Laboratory of the Carnegie Institution, located at Boston, in collaboration with E. P. Joslin, has made an exhaustive study of the influence of diabetes on the heat production of man. The peculiar disability of the diabetic organism to oxidize carbohydrate throws it back upon fat as the source of the greater part of its energy. According to their results, which agree well with similar findings in dogs made diabetic by artificial means at the Cornell University Medical College in New York City, the total heat production is increased by severe diabetes from thirty to fifty per cent. Benedict and Joslin believe this to be due to the stimulating effect of acid bodies produced from protein and fat, in the absence of carbohydrate combustion. Other results which have come from the Carnegie Nutrition Laboratory concern the heat production in women, both pregnant and non-pregnant, the heat production of hypophysectomy, etc. A calorimeter constructed in principle after the improved type of Benedict, has been set up by the Russell Sage Institute of Pathology in Bellevue Hospital, New York City, and is especially designed for the determination of the food requirement of bed-ridden and convalescent patients.

Calorimetry and the Economy of Food.—Atwater and his coworkers made numerous investigations on the heat value of human foods as purchased in the market and as prepared for use in the kitchen. This constitutes a very valuable body of information for any person wishing to compare different foods as to their cost and nutritive value, *i.e.* the real economy of food. The interested student can obtain bulletins setting forth these results in explicit form by writing to the Superintendent of Documents at Washington. Since the death of Professor Atwater, the calorimeter which was constructed under his direction at Middletown, Conn. has been reconstructed and set up in the Bureau of Nutrition in the Department of Agriculture at Washington. Investigations on the heat production of farm animals and on the influence of different kinds of food for fattening, etc., have been carried on extensively by Professor Armsby at the State College of Pennsylvania.

John R. Murlin.

Heat, Therapeutics of.—"Heat and cold are two conditions of the same force, caloric and, with reference to the human body, mean, respectively, the intensity of caloric above and below 98.4°F. (37°C.)." Hinsdale. Although heat has always been recognized as one of the most valuable therapeutic agents, it has never been so widely used as at the present time. It is one of the safest and simplest remedies known. Its good effects are varied and the methods of applying it are numerous. The results of the therapeutic use of the heat are dependent upon various conditions, chief among which are the manner of its application and the temperature.

The brief hot and the brief cold bath have practically the same results. This apparent paradox is due to the fact that both heat and cold are thermic irritants. Their brief application excites the sensory terminals of the peripheral nerves and the effect is stimulation. Prolonged application, however, brings about decidedly different secondary effects.

When heat is applied to the skin there is not only the direct local effect, but there are besides indirect reflex effects on the circulation in distant parts of the body. The latter are of great therapeutic importance.

The effect of hydrotherapeutic treatment is determined by the reaction of the body. Either air

or water may be employed as the agent but the latter is preferable on account of its greater specific heat and greater coefficient of heat conductivity (Hinsdale). The entire theory of reaction has been reconstructed by Dr. Simon Baruch. After warm applications there is little if any primary vasomotor action. By means of the warm bath, the cutaneous muscular structure is relaxed. The dilation of the capillaries is due to diminished resistance, and this weakens the action of the heart. This organ makes a compensation for its imperfect systole by increasing the number of contractions. Both local and general circulation become weaker, and arterial tension becomes diminished, the pulse becomes compressible, and there results the condition of atonic congestion. Thus the judicious warm bath is atonic and sedative.

When the cutaneous capillaries are dilated the skin becomes reddened, and if the temperature is not higher than 104° F. cutaneous sensibility is increased. When, however, the temperature is increased to between 110° and 120°, sensibility is diminished or even abolished.

The nervous system is soothed by a moderate degree of heat, but untoward effects such as headache and vertigo are caused by a high degree if the air is not dry.

Water bags, sand bags, Leiter's coils, cloths, bricks, flat-irons, and friction are among the agents employed for applying heat. In the algid state of cholera, for example, it must be remembered that clothing does not supply heat, it simply prevents its dissipation, so that special measures should be taken to impart heat to the body, such as surrounding it with hot-water bags and the like. Death from chloroform anesthesia is nearly always in consequence of heart failure. In such a case hot applications should be made to the cardiac region. External heat draws the blood to the periphery and thus relieves the heart.

By fomentation or cataplasm is meant the application of cloths wet with whatever liquid is used and applied to the part. The heat may be maintained either by renewing the cloths or by applying a hot object, such as a water bag or a brick to the cloths.

Poultices are not used now nearly so extensively as they were formerly. If they remain on the part too long they will lower the vitality and produce vesication or pustulation.

The use of the hot flat-iron in rheumatic troubles and the like frequently gives astonishing results. The effects seem often magical, the relief afforded by this homely household remedy being greater than by many of the methods which are in more general use. The affected part should be protected by several layers of flannel, and in applying the iron it should be held carefully so that the weight is supported by the hand of the operator while the patient obtains the full benefit of the heat. Hot applications to the abdomen cause constipation. This may be from two factors: from the decrease in intestinal secretions or from the decrease in peristaltic action of the intestinal musculature. Heat hastens eruptions. Hot baths relieve the various forms of abdominal colic, as renal and hepatic; also inflammation of the urinary apparatus. In dysmenorrhea, the hot foot bath is valuable. Heat applied to various regions of the spinal cord affects the organs which these nerves supply. This method is often successful in the treatment of metrorrhagia and menorrhagia.

The electric pad or thermophore and the electric thermophore blanket offer very convenient means for the application of heat. The local application of heat is also made by means of the photophore, and the arc-light. Both solar and electric light are employed, the latter being applied by means of the photophore, the incandescent electric-light bath and the arc-light bath.

Heat has many specific uses, some of the principal being as cardiac stimulant, counterirritant, diaphoretic, general sedative, general stimulant, germicide, hemostatic, hypnotic, local anesthetic, and local sedative.

Some of these effects have already been touched upon. As a cardiac stimulant heat is used universally in cases of shock and collapse, in drowning, exhaustion, asphyxia or debility of the new-born, narcotic and other forms of poisoning, in chilling if the patient is not frozen, and in any condition of heart failure. In such and various other emergencies, the application of heat is made to the extremities and precordia. Hot stimulating solutions, strong black coffee for example, slowly injected into the rectum are very useful. Intravenous infusion of hot saline solution is employed to stimulate a failing heart.

As counterirritant, it promotes absorption and hastens repair; it also removes passive congestion. In this connection it is often applied in the form of the actual cautery. This treatment is more valuable in chronic than in acute inflammation. It is sometimes indicated in deep-seated inflammation of the joints. The superficial layers of the skin only should be irritated. The cautery should be brushed over the part lightly, and be used at a white heat when vigorous counterirritation is desired, but at a cherry-red heat for hemorrhage. The relief from its use is often as great as it is sudden. It is indicated in neuralgia and rheumatic affections. Its action may be reflex through the nerves, producing a change in the nutrition of the part, with promotion of absorption.

The value of heat as a diaphoretic is well known.

Heat is a good general and local sedative. Heat draws the blood away from the great vessels to the periphery, dilating the vessels of this region and producing a feeling of general comfort. Heat is also used in the treatment of neuroses. Heat is employed in the treatment of the various muscular spasms including chorea. Hot applications to the face in toothache are very soothing. This treatment also relieves itching.

The general stimulating effects have been spoken of.

Heat is the most trustworthy germicide that we have. It may be used in the form of fire, dry heat, boiling, streaming or live steam, and steam under pressure. Fire is used only to destroy articles. Moist heat is a far more potent germicide than dry heat. Dry heat at 212° F. does not destroy pyogenic organisms in a period less than an hour and a half, while spores continue to live for three hours in dry heat of 284° F. On the other hand, all pyogenic organisms are destroyed in boiling water almost immediately. Spores, however, are more resistant and require the application of moist heat of 284° F. for no less than half an hour. Streaming or live steam is utilized in the ordinary sterilizer or disinfector. Steam under pressure is used to disinfect objects such as bales of goods.

Heat is used as a hemostatic in the form of the actual cautery, the galvanocautery, steam or of water raised to the temperature of 120° to 140° F. If the bleeding surface is large, the oozing should first be treated by compression with hot cloths to stop the capillary hemorrhage before the cautery is applied. The clamp and cautery method of treating hemorrhoids is well known. The Paquelin and galvanocautery are used much in nasal, laryngeal, rectal, and dermatological cases. For the purpose of arresting hemorrhage the cautery is used at cherry-red heat in order to make an eschar deep and strong enough to resist the pressure of the blood. Wounds thus treated heal by granulation. Care must be taken not to disturb the wound after operation on account of the risk of hemorrhage from shedding of the eschar.

Hot water not above a temperature that the bare hand can bear acts as a hemostatic by "stimulating the unstriated muscular fibers of the blood-vessels to contraction. The hemostatic effect is increased

by pouring hot saline solution, in a large stream from a pitcher, at some height over the surface of the wound" (Matas).

Victor Horsley advocates hot water irrigation at a temperature varying from 110° F. to 115° F. to control arterial and capillary cerebral hemorrhage. He sounds a warning against the use of a higher temperature for this purpose lest 120° F. cause heat coagulation of cut brain tissues.

Atmokausis consists in the spraying of steam on a bleeding surface. This method was introduced by Snegireff in 1886 to control parenchymatous hemorrhages and is used in gynecology.

In the process of atmokausis, steam is applied to the uterine mucosa through a fenestrated catheter. When the catheter is not perforated, the tube becomes heated by the steam and there results contact cauterization or zestokausis. These terms atmokausis (*atmos*, steam, *kausis*, burning) and zestokausis (*zestos*, to boil) were introduced by Pincus.

Heat is hypnotic, hot baths being very beneficial in acute and chronic insomnia.

A high degree of heat may be used as a local anesthetic, since it has the faculty of blunting the perception of different kinds of sensation at certain temperatures, as mentioned before.

Baths of various kinds are also used for applying heat; continuous baths (the warm full bath), hot-water baths (104° to 115° F. (40° to 46.1° C.), the Turkish bath (diaphoretic), the Russian bath (diaphoretic), vapor or sweating bath, the Irish-Roman bath, the evaporation bath, the hot-air bath, and the electric-light bath, the "half-bath" of Priessnitz, the hot foot-bath, warm or hot baths medicated by the use of various substances such as mustard, sodium bicarbonate, pine-needle oil; "Nauheim" baths, carbonated baths, acid baths (Kish), effervescing baths, oxygen baths, mud baths and fango packs, mud and peat baths, sand baths, sitz- or hip-bath; packs—hot wet packs, dry hot packs; fomentations or hot compresses; the salt rub or salt glow which is begun in a tub of salt water at 104° to 105° F. (40° to 40.5° C.); douches (which may be applied to special parts of the body)—needle douche, needle spray, circular douche, rain douche, Scotch douche, fan douche, filiform douche, steam douche, Aix douche, Corbin douche, Vichy douche, indirect or undercurrent douche, percussion douche, pail douche or pail-pour, hot lumbar douche, Fleury douche modified by Raymond and Duchenne. The control table is an apparatus which greatly simplifies the administration of all forms of douches.

The douche is used chiefly in gynecological, nasal, and aural troubles. For pelvic inflammations and congestion the hot douche is most valuable. The good effects are dependent upon the temperature used, and upon the length and the manner of application. The temperature of the irrigating fluid should be as hot as can be borne. The application should continue for at least twenty minutes and the patient should lie on the back with the hips elevated.

Mud baths and fango packs are used in rheumatism, gout, arthritis deformans, and the neuralgias. Their effects are due chiefly to the heat applied. Hinsdale likens the fango to a great sterilized poultice for it both conveys heat and retains it. When this pack is applied to a joint or limb, its effects are: "stimulation of cutaneous reflexes, with dilatation of superficial capillaries; increased activity in the normal processes of absorption of morbid deposits, and repair of damaged tissues. Perspiration is promoted and there is a slight increase of body temperature, 2° F. (1.1° C.), subsiding rapidly after the removal of the pack, and due to direct conveyance of heat to the blood."

Peat baths (Moorbäder) are applied also as immense poultices. They may be used locally or generally. Mud baths (Schlammbäder) and moor baths of high temperature may be employed because the mud and peat are comparatively poor conductors of heat. Peat baths are beneficial in rheumatic affections, lumbago, gout, sciatica, and in chronic pelvic affections. In the neuralgias, low temperatures, 113° F. (45° C.), should be used. Sand baths are useful when it is desirable to raise the body temperature and markedly excite the skin.

The Turkish and Russian baths are well known for their good effects in the treatment of many affections, such as coryza, gout, and rheumatic troubles. But in recent years, various new devices have been introduced by means of which the patient may be exposed with comfort to the beneficial effects of an extremely high temperature, for example 330° F., and even higher, because the air is kept dry. Before apparatus was devised by means of which the air could be kept dry, the evaporated perspiration gradually rendered the surrounding atmosphere moist, and the perspiration on the skin actually scalded it. On this account the Turkish bath cannot practically be higher than about 170° F.

In the treatment of typhoid fever by baths, the physician must take the behavior of the blood-vessels as his guide for the choice of the temperature. In certain cases showing marked toxemia with the temperature below 102.5° F. (39.2° C.) the full tepid, warm or even hot (104° F. 40° C.) bath with friction is indicated.

Hot sponging is sometimes substituted for the Brand bath in the treatment of very nervous patients or children. The sponging with water at about 110° or 112° F. (43.3° or 44.4° C.) is followed by a quick rubbing with warm alcohol.

Opinions vary as to the hydrotherapeutic treatment of measles, but lukewarm baths, 96° to 98° F. (35.6° to 36.7° C.) are commonly used.

Hot full baths at 103° F. (39.5° C.) raising the temperature during the bath to 106° or 107° F. (41.1° or 41.6° C.) are found to be very stimulating in cases of threatened collapse.

The lukewarm or hot bath may be used in mild cases of scarlet fever.

In chorea, a tub bath of 90° to 98° F. (32.2° to 36.7° C.) gradually cooled 10 or 15 degrees is often employed.

Warm baths, 104° F. (40° C.) are indicated in cerebrospinal meningitis. In the convulsions of children the hot bath may be given.

In tetanus warm baths and the hot pack are employed.

In the early stage of yellow fever a hot mustard bath or foot-bath is indicated.

In the collapse of cholera the hot bath, 104° to 105° F. (40° to 40.6° C.) is used. Hot wet packs may be substituted for the baths.

For tuberculous patients many physicians advocate the use of water at 90° F. (32.2° C.) or higher in the form of bath or doucne. The water of the bath is gradually cooled. Especially in childhood, various affections of the respiratory tract, such as bronchial catarrh, are relieved by this treatment. The sedative effect brings sleep and makes breathing less labored. The affected membranes are relieved of the surplus of blood, which is drawn to the periphery. The patient must be carefully watched and not be allowed to become weak from the treatment, as the secondary effects of a too long-continued hot bath are debilitating.

In certain cases of bronchopneumonia and capillary bronchitis in children hot baths, 100.4° F. (38° C.) may be given.

The short warm bath, 90° F. (32.2° C.) varied with cool douches is used in asphyxia neonatorum. Acute bronchitis is treated by the hot mustard foot-bath or full bath.

For stimulating the secretions, Lissauer uses the steam douche.

The hot bath and the warm pack are used by many clinicians in active congestion of the lung.

The mustard pack at lukewarm temperature is highly recommended by Lenhartz for treating edema of the lung.

In influenza, epidemic catarrhal fever, hot applications are preferable to cold ones.

Opinions of authorities concerning the sweating process in the treatment of renal diseases vary widely.

Patients with chronic interstitial nephritis are best treated with hot applications. Moist heat is preferable unless edema threatens. When uremia exists, the cerebral symptoms are often entirely relieved by the hot-water or vapor bath, for by this means not only the skin acts freely, but the effect on the whole organism is sedative, pain and irritability being allayed.

The full warm bath followed by a rain bath or a fan douche is advocated for patients with high nervous tension but without arteriosclerosis.

The hot douche forms part of the modern treatment of nephritis with edema.

In mild cases of the toxemia of pregnancy simple warm baths, and in severe cases hot packs are indicated. Hot packs and vapor baths are demanded in uremia and in eclampsia. A certain country practitioner used to apply hot ears of corn covered by a few husks.

For infants and young chlidren suffering with scarlatinal nephritis warm baths, 100° to 101° F. (37.8° to 43.3° C.) are used.

In diabetes mellitus, the daily warm cleansing bath, and the continuous or hammock bath at 95° F. (35° C.) are indicated. Warm baths form part of the treatment of diabetes insipidus.

In the treatment of chronic articular rheumatism and the arthrites the systematic application of heat is universally recognized. The value of thermal springs in these cases has been recognized since early times.

The application of heat of different degrees and by different methods forms a valuable part of the treatment also of acute rheumatism, the cerebral form of rheumatism, muscular rheumatism, rheumatic endocarditis, gout, gonorrheal arthritis, and arthritis deformans. Among the methods used are the hot tub bath, the hot douche, the hot pack both wet and dry, the hot-air bath (baking), fango compresses, moor baths or packs, hot-sand baths, and electric-light baths.

Heat in various forms comprises an important part of the treatment of diseases of the heart and vascular system.

Heat is one of the most valuable measures in the treatment of alcoholism, morphinism, chronic lead, mercury, arsenic, and tobacco poisoning.

Heat is a most useful adjunct in the treatment of various digestive disorders—certain forms of constipation, gastroptosis, chronic gastritis and enteritis, round ulcer of the stomach, cholera infantum, and sea-sickness. Heat plays an important part in the therapy of anemia, chlorosis, convalescence from acute illness, neurasthenia, insomnia, insanity, melancholia, headache; in the neuralgias, paralysis, locomotor ataxia; in obesity, exophthalmic goiter; syphilis and various skin diseases.

The results of hydrotherapy both local and general are most happy in many surgical affections. The improved circulation with the resulting increased oxidation added to the general tonic effect of bathing are the potent influences for improvement.

Chief among surgical affections amenable to these measures are local inflammation, diseases of bones and joints, sprains, felons, furuncles and phlegmons, surgical shock, football injuries, phagedena, burns and scalds. Local hot baths for felons, furuncles, and phlegmons are used in Germany and Austria. The length of the bath is from 30 minutes to an hour and is taken several times a day. The temperature is as high as can be borne. These measures are analogous to those of passive hyperemia recommended by Bier. Schäffer of Breslau has made a most scholarly investigation in relation to the treatment of inflammation. The results of his work show that the employment of hot poultices to favor the "pointing" of an abscess is logical. He has demonstrated also that with this treatment, after incision of the abscess "the pus is thinner, more watery, discharges more freely and completely, and, what is more, a smaller incision is necessary over the pointing abscess."

Schäffer's figures for the upper limit of temperature of moist and dry heat respectively that are beneficial in applications are 41° C. (106° F.) and 45° C. (113° F.); with higher temperatures, "capillary hemorrhages occur with marked stasis and leucocytic infiltration."

In the local treatment of inflamed tissues, it should be remembered that heat is preferable to cold when the affected tissues are soft and yielding, as in pain at the root of a tooth. In burns and scalds one of the most successful methods of treatment is by means of the continuous bath at a constant temperature of 98° F. (36.7° C.). The patient is taken out of the bath daily in order that sloughs may be removed. The disagreeable odor is obviated by this method. The continuous warm bath is very beneficial in minimizing the serious effects on the nervous system of extensive burns. Sloughing wounds and eczema are also treated by this method. The patient eats and sleeps in the bath with the greatest comfort. For many years Kaposi of Vienna has employed the continuous bath in his wards with great success. Genito-urinary diseases in both men and women are successfully treated by continuous baths and irrigation of the bladder by water at about 100° F. (37.8° C.). Gynecological affections are treated according to indications by warm or hot baths or douches, packs, and other measures. The Nauheim baths are useful in a variety of gynecological disorders. Various external and internal ocular affections are relieved by the application of heat. Among these are conjunctivitis neonatorum, phlyctenular conjunctivitis, vitreous opacities, chronic iridochoroiditis, detachment of the retina, toxic neuritis, and hemorrhage into the vitreous and retina, inflammation of the uveal coat, the chorioretina, and the optic nerve. Hansell and Risley advocate the hot packs and electric-light baths. In case of glaucoma a short hot foot-bath may prove useful. Toothache is sometimes complained of by patients after hydrotherapeutic measures. "This is not neuralgia, but merely the flaring up of some latent carious process." (Hinsdale.) Kraus terms such phenomena "Provokationserscheinungen."

The superficial application of heat and cold to the living human body is generally believed to have a temperature effect upon the deeper structures. After weighing the evidence of various investigators, however, this statement can be accepted "only to a very limited and comparatively superficial extent."

Proctoclysis is the recent method by which water at a temperature of 100°F (37.7°C.) containing radium chloride and calcium choloride is gradually introduced into the rectum, from 50 to 80 drops a minute escaping at very low pressure. Dr. John B. Murphy advocated this method in the treatment of peritonitis. It has proved most successful in such cases. Rectal and colonic rectal irrigation are valuable adjuncts to hydrotherapy.

Hot-water drinking was more in vogue some years ago than it is at the present time. Taken as a draught in small quantities, hot water causes a temporary rise in the pulse-rate but lowers the blood pressure for about the same length of time. The drinking of hot water is counterindicated in heart disease with failure of compensation. Warm drinks taken at bedtime often allay cough.

The diseases that have of late years been treated with benefit by means of electrically heated ovens are the arthritic diseases—rheumatic arthritis, gout, rheumatism; joint affections, such as sprains; affections of the nerves, as neuralgia, sciatica, and the like; certain skin diseases; chronic ulcers, and flat foot.

Still other apparatus has been devised by means of which the body is subjected to the action of radiant heat. The diaphoretic effects of combined heat and light are said to be much greater than the same degree of non-luminous heat. The effect of the electric heat waves is invigorating and tonic. One result of these exposures to extremely high temperatures, one that is contradictory to former physiological teaching, is that the body temperature is raised several degrees. The following suggestion has been made in explanation of cases in which certain parts of the body are exposed to the heat: "It is probably due to imperfectly coordinated diaphoresis in parts of the body other than that exposed to the direct heat of the bath—that is to say, the blood as it flows through the heated area is not completely cooled down before it passes on to other areas, where the conditions are different, and where reflex, superficial, vascular dilatation, and consequent diaphoresis, are not correspondingly established." In the application of these methods just mentioned, the apparatus is so arranged that the head of the patient remains free in the normal room temperature. Besides great local benefit, the general health is improved by these hot baths. In the radiant-heat bath the perspiration, as soon as it appears, is evaporated by the hot dry air. If this heat is applied locally, the circulation of the part treated is increased and not only is extra nutrition supplied, but a greater amount of blood is carried away from the part; and it is probable that this blood takes away from the diseased area many morbid products in solution. When radiant heat is produced by electricity, the advantages can be clearly seen, as there is no combustion and the patient breathes perfectly pure air. Among the affections treated with benefit by this method are the following: rheumatoid arthritis, gout, chronic cramp, sciatica, fixed joints, inflammation of the veins, adhesions following fracture, chronic articular rheumatism, chronic alcoholism, rheumatic gout, stiffness following injury, gonorrheal rheumatism, vasomotor disease, epilepsy, chronic Bright's disease, asthma, bronchitis, strumous ulcers, fracture, spinal disease, chorea, and peripheral neuritis. The general effect of the radiant-heat and light bath is soothing, as it allays pain and imparts a feeling of well-being.

Moist diabetic gangrene has been recently treated by douches of dry, superheated air, and this method has proved to be a valuable adjunct. There results rapid desiccation, disappearance of pain and odor. Bacterial growth and absorption are checked. Recuperation may take place to the extent of strength for operation—amputation of the limb. In cases of less severity operation may be avoided.

The mode of administration of the douches consists of the daily application during one-half or three-quarter hour sittings of a stream of heated air, constant or interrupted, by means of an electric apparatus of special construction.

The living as well as the dead tissues are included in the treatment so that an active hyperemia is produced. Air heated to a temperature of from 200° to 300° C. and exceptionally 700° (Ricard) is used on the gangrenous parts, while a temperature varying from 80° to 100° C. is applied to the healthy parts.

Various authorities report very happy results not alone in diabetic gangrene but in certain cases of moist gangrene due to various other causes such as arteriosclerosis, in which immediate operation is not advisable. This treatment is sometimes employed also in frost-bite especially in anemic patients in whom the condition is practically chronic. In the case of acute frost-bite in delicate patients, Bier's passive hyperemia is more suitable.

Aerotherapy has proved useful in the case of painful joints and sciatica. Various powerful derivative effects occur through the resulting hyperemia of the skin. Gouty nodules have been absorbed by the use of this method.

The term fulguration (lightning) used first to designate the de Keating-Hart method of treating cancer by high-frequency discharges of electricity, has in many cases been loosely employed in relation to other methods.

The term "destructive fulguration" has at times been used to designate the treatment of neoplasms both benign and malignant by the ordinary high-frequency electrocauterization (Bainbridge).

Clark describes the method of oscillatory desiccation practiced by means of a specialized high-frequency current. He calls attention to the range in degree of heat effects—from hyperemia to burning. The so-called desiccation point is between these extremes.

Thermopenetration (d'Arsonval) is the method by which a rise of temperature is brought about in tissues placed between two electrodes by the employment of the high-frequency current.

Diathermy or transthermy (Nagelschmidt) is a thermic means of destruction employed in the treatment of neoplasms. By this method the high-frequency current by its thermo-penetrative power destroys the tumor by coagulating the tissues.

Different degrees of heat are employed for different conditions, for rheumatism, sciatica and like conditions are treated by this method. The effect is a sensation of heat felt deep in the tissues but not on the skin.

The passage of the current through the body causes not alone local increase in temperature, but general rise also together with diaphoresis. Various conditions benefited by diathermy have been reported, among these being Bright's disease, cardiac disease with dropsy, bronchopneumonia, bronchitis, asthma, pleurisy, rheumatism, gonorrheal rheumatism, lumbago, and joint affections including acute gout; sciatica, tic douloureux, nervous headache, neuralgia, locomotor ataxia, obesity, insomnia, myocarditis, and in pelvic exudates.

Doyen devised a special apparatus more powerful than that of Nagelschmidt for the thermic death of cancer. This method is known as electrocoagulation and is used to destroy neoplasms of the skin and mucous orifices. Nagelschmidt sums up the advantages of this treatment as follows: "Electrocoagulation can be used in those tissues inaccessible to the knife; it destroys bacteria and their toxins; it is hemostatic; it favors elimination of cancer cells in the neighborhood, because of the lymphorrhea; it prevents dissemination of cancer cells during the operation for the lymph and blood-vessels are coagulated; finally, it is not specific, and results depend upon correct technique."

When a superficial carbonization is caused by holding the electrode away from the part the term bipolar voltaization is used.

A method of thermopenetration called thermoradiotherapy refers to the process of heating the diseased tissue with a cooling of the skin. In this way the tissues are rendered more sensitive to the *x*-rays.

Although the uses of heat are at present so varied and valuable, this field is probably yet but in its infancy, as new discoveries and improvements are constantly being made in this department of therapeutics.

EMMA E. WALKER.

Heat-stroke.—(Synonyms: Sunstroke, insolation, thermic fever, *siriasis*, *coup de soleil*, *coup de chaleur*, *Hitzschlag*, *Sonnenstich*, *ictus solis*, *insolatio*.)

Definition.—Insolation is a disease whose main features are, in its milder forms, intense exhaustion, with or without rise of temperature, and in its severer forms, with an enormous rise of temperature and coma probably caused by acute autointoxication due to the presence in the blood of toxic decomposition products or toxic substances produced at the unusually high temperature, the exact nature of these substances being at present unknown.

From the time when it is recorded that Elisha restored the Shunammite woman's son to life after a sunstroke the frequency of this affection has often been noted. Armies at times have been almost decimated by it, especially when operating in subtropical or tropical countries. Sunstroke occurs most frequently in the tropics, particularly where the climate is damp. In the United States it occurs during summer in the Mississippi Valley, around the southern shores of the Great Lakes, and especially along the Atlantic coast. In the Western and Southwestern States it is rare, owing to the dryness of the climate.

Any cause that diminishes the resistance of the body predisposes to sunstroke. Alcoholism is undoubtedly the most frequent predisposing cause, not only chronic alcoholism but even a single excess. All causes producing extreme fatigue, such as severe muscular exertion and sexual excesses, predispose to an attack. Elderly people suffering from chronic ailments and invalids of any age, even if taking no bodily exercise and remaining indoors, are sometimes overcome by the heat and suffer true attacks of heat-stroke. It is not so common among children as among adults. Men are more frequently attacked than women because their occupations more often subject them to different forms of exposure to heat and require of them greater physical exertion, and because men are more often given to alcoholic excess than women.

Exposure to the direct rays of the sun is usually the exciting cause, but this is not necessary; some of the worst epidemics in the tropics have occurred during the night. While soldiers on the march and laborers working in the sun have given the greatest number of victims to this disease, men working in superheated environment such as firemen, stokers, and laundrymen have often been attacked. The main factors in the weather which are specially prone to assist in the causation of insolation are high humidity with continuously high temperature and lack of motion of the air. Humidity and especially the absence of cooling breezes are as important factors as is high temperature, although the cause of sunstroke is usually attributed to the high temperature alone. It has long been noticed that a hot, sultry, lifeless atmosphere is the one in which most cases of sunstroke occur. Impurity of the atmosphere is not unimportant, as is shown by the fact that men sleeping in crowded barracks or small tents are more often victims than those in well-ventilated quarters.

Sunstroke occurs with greater frequency in the tropics among unacclimated individuals than among those of long residence, who have acquired a certain amount of immunity to the effects of heat. This immunity, however, is by no means absolute, as even the natives of India, Egypt, Arabia, and Africa are at times overcome. The light-skinned races are more susceptible than the dark-skinned.

Pathological Anatomy and Pathology.—The postmortem appearances depend on the time that has elapsed since death occurred. When the postmortem examination is made shortly after death the following conditions are usually present: When the antemortem temperature has been high the viscera feel noticeably hot; the lungs are congested, often extremely so; the liver is large, and the abdominal veins are filled with blood and there is intense congestion of the brain and meninges. The left ventricle of the heart is contracted and empty; the right ventricle is filled with semifluid blood, sometimes giving an acid reaction. Rigor mortis has set in early. When several hours have elapsed since death decomposition will already have set in. The heart, instead of being contracted, is then flabby and filled with grumous, semifluid blood. The spleen is slightly enlarged and soft. The meninges of the brain are congested, and there is more or less abundant subpial fluid. The brain itself is usually firm and not congested, with sometimes a little bloody fluid in the ventricles. The membranes of the spinal cord are congested, the cord being firm and about normal in appearance. Small hemorrhagic extravasations are sometimes found in the viscera, pleuræ, and pericardium. The most constant changes seem to be marked congestion of the meninges and viscera, the fluidity of the blood, and the unusual rapidity with which rigor mortis and decomposition supervene.

In the minute cellular structure of the brain we find changes which are much more constant and which are fairly characteristic. Dr. Ira Van Gieson, of New York, has described these lesions in the neurons of the brain and cord, as an acute parenchymatous degeneration of the ganglion cells best shown by the Nissl stain and counterstain with eosin. In the normal cell stained in this manner the chromophilic plaques, or Nissl bodies, appear to have a somewhat barrel-stave shape and to be somewhat thickly packed in the body of the cell. In insolation the appearances are strikingly different. In the early stages of degeneration the chromophilic plaques are divided into large and small segments, and in other places appear fused together in a confluent condition, and they show changes in form, having rounded ends or are oval or spherical, and are abnormally few in number. In other cells the chromophilic plaques show further disintegration, and have been converted into fine, dust-like particles strewn about over the cytoplasm, giving it a finely granular, almost homogeneous appearance. The outlines of these cells are much less distinct than normal. These appearances seem to be more often found in the anterior horns of the spinal cord, where the changes do not seem to have advanced so far as in the cerebral cortex and cerebellum. When the changes are further advanced the chromophilic plaques are not only converted into dust-like particles, but in some cells the particles have disappeared, giving to the cell body a pallid, shadowy outline. The changes in the nuclei may also be marked and radical. The nuclear membrane is uneven in outline, notched in places, and slightly crenated; the nuclear fluid is changed in consistence, so that it appropriates methylene-blue stain very freely. This is in distinct contrast to the normal. In some cells the nuclear contents appear homogeneous, while in others there is a fine granular content. In some cells the nucleus seems to have entirely disappeared. In none of the ganglion cells of the cerebral cortex, cerebellum, and spinal cord which have been examined, has there been any distinct evidence of destruction of the cells. There have been no vacuoles nor loss of substance in the cytoplasm. The cells have preserved their form, with the exception of the various phases of dissolution of the chromophilic plaques. In the cerebral cortex these changes occur in both motor and psychic cells.

The changes thus described are simply those produced by the operation of a great variety of poisons, as lead, alcohol, the microbic poisons, and autointoxications. It is therefore evident that a chemical reaction has occurred between the poison and the constituents of the cells. By the method of elimination and excluding other groups of poisons, these changes having been found in the nervous systems of patients in whom alcoholism can be positively excluded, it is justifiable to conclude that the lesions found in cases of insolation are from some kind of autointoxication. This toxic resolution of the gang-

lion cells may not necessarily go on to destruction of the cells.

L. W. Sambon has brought forward the idea that sunstroke is due to microbic infection, basing his opinion on the fact that the cellular lesions cannot be distinguished from those of microbic infections, and upon the symptoms, relapses, its peculiar geographical distribution, epidemic outbreaks, condition of climate and soil under which it prevails, and the relative immunity by acclimatization. He has given the name "*siriasis*" to this disease. The reasons advanced by this author do not seem to be sufficient to justify this opinion, and the history and circumstances under which the various epidemics have occurred point strongly against the microbic origin.

The changes in the cells of the other viscera also seem to be those of acute parenchymatous degeneration. These are especially noticeable in the liver and kidneys. The blood in sunstroke also undergoes certain marked changes. The number of red cells seems increased, but this is probably only apparent, being due to the condensation of the blood from loss of fluids through excessive sweating. The hemoglobin in twelve cases gave from eighty-five to one hundred and twenty-five per cent., averaging one hundred per cent. The increase above the average normal was probably also due to blood condensation. There seems also to be destruction of the red cells, as the leucocytes are found to contain pigment. The pronounced anemia following sunstroke also points to the destruction of the red cells. These blood changes occur not only in patients who have suffered from hyperpyrexia, but also in those whose temperatures do not rise above 105° F. As the red cells do not disintegrate from heat until the temperature rises to 125–129° F., the destruction observed in insolation points definitely to some toxic elements in the blood. The blood serum of sunstroke patients has also been shown to be exceedingly toxic to animals. Levene and Van Gieson found that 9 c.c. injected into the ear veins of rabbits killed the animals in less than an hour, normal human serum having no such effect.

The gases in the blood, however, seem to remain normal. Wood and other observers have reported that the alkalinity of the blood in individuals dying of sunstroke is greatly diminished, and in some instances the reaction is distinctly acid. Levene and Van Gieson have also found that the urotoxic coefficient was diminished in the urine of sunstroke patients, while it was increased in the urine of the same patients during the first twenty-four to forty-eight hours of recovery. This seems to point to failure of elimination of toxic substances during sunstroke. Arloing has found that the sweat during severe muscular exercise is two or three times more toxic than that of the same individuals at rest. When sweating ceases in sunstroke there would seem to be an accumulation of these toxic substances.

Based on the above lesions and experimental observations, the clinical symptoms of the various forms of sunstroke are more readily explained and understood than by the theory that heat alone within the body was the sole cause. The changes in the cytoplasm in the ganglion cells show the injury to the functional activity of the cell, while the changes in the nucleus show processes detrimental to cell life.

The prodromal symptoms of the severe forms of sunstroke are those of severe functional disturbance, while the later symptoms of the severe forms show a tendency to destruction of the neurons. Heat undoubtedly is the main contributing cause of sunstroke, as exposure to cold is of pneumonia. From whatever source the heat comes the action on the body is practically the same.

The even temperature of the normal body is due to the maintenance of the equilibrium between heat production and heat loss. Young persons with healthy eliminative organs will stand a high degree of temperature and long exposure to the effects of heat. Equilibrium is secured by the contraction and dilatation of the skin capillaries and increase and decrease of perspiration, with the consequent increase and diminution in radiation and conduction of heat over the body. There are also said to be nervous centers controlling the production of heat, but their exact location and action are not fully determined.

Heat is produced in the body by chemical metabolism constantly acting, especially during muscular exercise. Normally 2.6 per cent. of heat is lost from warming food and drink ingested; 2.6 per cent. by warming the inspired air; 14.7 per cent. by evaporation; and 80.1 per cent. by radiation and conduction through the skin.

Sunstroke occurs with greatest frequency among persons performing some form of bodily exercise in an intensely hot environment. The heat production of the body is thus at the maximum, while the heat loss from warming the inspired air is zero. The loss from radiation and conduction is also zero, the air being as warm as or warmer than the body. If sweating is excessive, heat loss may be sufficient to maintain the equilibrium; but if sweating ceases, as it usually does in insolation, heat loss ceases and heat production continuing, the heat rapidly accumulates in the body, and thus an enormously high temperature is brought about.

Goldschieder and Flatau have shown that the neurons of the central nervous system of animals whose temperatures have been artificially raised to 109.4° F. seem to show the same changes when stained by the Nissl method as those described above. The neurons of living animals whose temperatures have remained for three hours at 107° to 107.6° F. also began to show the same changes. But when the animal had been previously killed and the temperature of the body raised to 112.3° F., the cells did not change. Heat alone, therefore, will not produce these changes, and the action must be one of chemical metabolism in the living cell protoplasm. In sunstroke patients at times die, the temperature never having gone above 106°. This temperature in diseases of microbic origin is borne without causing death, hence the amount of heat *per se* in the body does not cause death in these cases of sunstroke.

Most authorities state that a temperature of 113° F. is necessarily fatal, but a patient suffering from sunstroke was admitted to the Presbyterian Hospital, in New York, with a temperature of 115° F., and recovered. The limit of temperature which can be borne by the body with recovery can, therefore, not be definitely stated. In infectious diseases it is the lesion produced by the causal agent and not the temperature which kills; in sunstroke it is the metabolic changes in the central neurons and not the heat.

As to the definite cause of death in sunstroke, many theories have been advanced. Sudden coagulation of the cardiac muscle due to heat does not seem a tenable theory. While it is true that on the battlefield men have been known to drop from sunstroke and become rigid, dying almost instantly, heat coagulation of the heart muscle does not occur below a temperature of 122° F. or higher, while many patients die long before such a temperature is even approached, and the highest temperature ever recorded in sunstroke is 117.8° F. Death is also not due to lack of conduction in the nerve fibers, as these do not lose their power of conduction to impulses until a temperature of 125 6° F. is reached. It would therefore seem to be due to some toxic action on the cardiac and respiratory centers at whatever temperature this action may occur. In the most accurately recorded experiments on animals respiration ceased before the heart. Clinically there seems to be simultaneous failure of heart and respiration, but at times first one ceases, then the other. As will be seen later, the prodromal symptoms of insolation are those of disturbance of the digestive tract and liver.

Food is badly assimilated, there is indigestion in the stomach and in the intestines, and sometimes slight jaundice. Abnormal substances are thus produced in the digestive tract and liver. This causes headache and malaise. When severe muscular exercise adds its decomposition products to the circulation and at the unusual high temperature of the blood, abnormal chemical changes may take place.

The milder forms of sunstroke known as heat prostration, or exhaustion, are therefore due to a mild form of autointoxication, and are but the prodromal period of the severe forms, the neurons being but functionally disturbed. If the intoxication is more severe, syncope and unconsciousness occur. Heat loss due to great dilatation of the skin capillaries is sufficient to prevent accumulation of heat. Heat loss may be so pronounced and predominate over heat production that lessening of temperature may occur. When the intoxication is very severe unconsciousness may develop suddenly with or without prodromal symptoms, and the vasomotor, cardiac, and respiratory centers are affected. Heat loss being abolished, and heat production and accumulation being at a maximum, an enormously high temperature is developed. The neurons are so severely poisoned that their functions are abolished and convulsions, delirium, coma, and death supervene.

Symptoms.—The mildest form of sunstroke is heat prostration or exhaustion. An unusual weakness following exertion in hot weather most often seen in feeble persons is probably the mildest form that occurs. In more vigorous individuals the symptoms of this form are more pronounced. Exhaustion may come on suddenly without prodromal symptoms, or there may be prodromal symptoms followed by complete exhaustion. There are usually headache, dizziness, pain in the back and legs and epigastrium, with sometimes tingling of the hands and feet. These symptoms may continue for a few hours or for three or four days, and are sometimes accompanied by anorexia, nausea, and vomiting, or there may be diarrhea or constipation. Some patients show slight jaundice of the whites of the eyes. Uncommonly in this form of sunstroke perspiration may cease. While the patients are suffering from the prodromal symptoms they may be able to sleep and awake refreshed, but as soon as they attempt to go about their usual occupations after a varying length of time the prostration becomes so extreme that they are forced to give in to it. The headache is intense, either frontal or occipital, and the patient seems dazed; consciousness is retained. The respirations are slightly different from normal, 24 to 28 per minute. The pulse may remain normal in frequency, or, depending upon the intensity of the exhaustion, it not infrequently runs as high as 130 to 140 per minute. It is, however, of good force and tension. The temperature may be normal or even slightly subnormal, though as a rule there is a rise and the temperature may reach 104.8° F. Under proper treatment the temperature may become normal in a few hours, the other symptoms abate, and the patient rapidly recovers, or the symptoms may continue and there may be a slight thermic fever for two or three days, even a week, the temperature ranging from 99° to 103° F., gradually falling to normal. Cases have been observed in which a slightly elevated temperature has been maintained for fifteen days.

In moderately severe cases there is always loss of consciousness, but the temperature does not reach the hyperpyrexial level of 105° F. The same prodromal symptoms may be present as in the mild form, and at other times there is an intense feeling of burning and heat and "pins and needles" in the head. Sometimes there are alternating hot and cold flashes over the body with sweating. Vomiting and anorexia are often severe. Perspiration may cease a short time before unconsciousness occurs. Just before loss of consciousness there are noticed in some patients sudden dizziness and dyspnea, sometimes with chromatopsia. In other patients there is no premonition of the attack.

These symptoms may occur while the patients are at work or they may be suddenly overcome while quietly walking in the street at night. Suicidal tendency is sometimes developed just prior to loss of consciousness; sailors have been known to try to throw themselves overboard, soldiers to attempt suicide with their rifles. This temporary mental aberration may continue for a week or two, and then be followed by complete recovery. In some cases of this class there are, with the loss of consciousness, symptoms of complete collapse. Wood reports a case with a temperature of 95° in the mouth. Temperatures of 96° to 97° are not uncommon. The majority of these patients, however, show a rise of temperature between 101° to 104°. Except in cases of collapse the pulse is full and of good force and tension, though it may be as high as 130 per minute. Respirations may be normal or as frequent as 40 a minute, being usually shallow; the stertorous breathing of the severer forms is not present.

Physical examination will show coated tongue, skin hot and dry or covered with profuse sweat, and the patient may be conscious or totally or partially unconscious. The pupils react to light slowly and are sometimes dilated. Slight convulsive movements may be present, or there may be a restless delirium with moaning and groaning. Not infrequently there is a peculiar dark-pink, petechial rash on the body, different from the ordinary prickly-heat rash.

The changes in the blood enumerated above occur in this form of sunstroke as well as in the hyperpyrexial form. Unconsciousness, delirium, and other symptoms may persist for a few hours after the cold bath; sometimes consciousness is not regained for twenty-four hours.

Thermic fever when present persists for several days or a week. Patients usually recover from this form of sunstroke. This degree of insolation seems to be the least common. In two hundred and twenty-four cases of different types of sunstroke coming under the writer's notice in Bellevue Hospital in 1896, there were but eighteen of this type.

The severest form of insolation is the hyperpyrexial type. In this class are included all patients whose temperature rises to 105° F. and over, with or without loss of consciousness. The prodromal symptoms when present are often more pronounced than in the lighter cases, though many cases of this severe form of sunstroke have no prodromal symptoms at all. Patients whose temperature rises above 108° are less likely to have prodromal symptoms than those in whom the temperature is not so high. The worst attacks of sunstroke, therefore, may apparently occur without warning. The same prodromal symptoms are often present as in the milder forms; Insomnia, however, is marked, and may be present four or five days before the attack culminates. There are often great irritability and restlessness and sometimes decided increase in micturition for several days. A feeling of intense heat throughout the body, with the sensation as if the head were bursting open and the eyes bulging outward, is often noticed just before loss of consciousness. Chromatopsia is not uncommon, external objects taking on different colors, blue being the most common, or the field of vision may be occupied by brilliantly colored flames. In other patients objects suddenly lose color and appear black. Previous to loss of consciousness there are sometimes hallucinations of hearing or sight. Suicidal mania may also develop. Some patients are able to continue work which requires intelligent action and perform complex acts working with machinery, or may leave work and go home, undress, bathe, and go on the street again

before falling helplessly inert, and yet after consciousness is regained retain no memory of what they had done for several hours previous to the time when they were seen to fall. When consciousness is retained the patients suffer intensely with burning heat and intense headache, and may become stupid and dazed. Retention of consciousness in these severe forms of sunstroke is the exception. In patients with a temperature above 109° I have never seen consciousness retained. Most patients are comatose. The skin is dry, flushed, and hot; or it is livid, pale, and cyanotic, and covered with cold, clammy perspiration. The glazed, set eyes are suffused and half open, or may be wide open and staring. The pupils are at times normal, or may be dilated or contracted unevenly. They may or may not react to light. Respirations come in short gasps, often irregularly, with a noisy, gasping inspiration and quiet expiration, or with explosive expiration and quiet inspiration, often accompanied with a piteous moan. Some cyanotic patients lie absolutely limp and flaccid, not moving even an eyelid, while in others there may be convulsive twitchings or violent epileptiform convulsions. Other patients with dry, hot skin are wildly delirious and fight and struggle furiously. In the limp patients the pulse is usually soft and frequent or small. In the more sthenic cases it may be full, strong, with throbbing carotids. In the worst cases the patients are pulseless. Vomiting and involuntary defecation are very common. The urine is scant, sometimes albuminous, sometimes containing blood. The peculiar petechial rash is often present, being most abundant upon the arms and body.

These sunstroke patients emit a peculiar, characteristic, disagreeable odor, particularly strong in the feces, though it is distinctly not a fecal odor.

The cyanotic type of sunstroke occurs more often with temperatures above 109° F. than below this figure. The height to which the temperature can go is unknown. The highest reported temperature is 117.8°, in a patient brought to the New York Hospital in 1896. Another patient in the Presbyterian Hospital, New York, had a temperature of 115°. These temperatures were measured with special thermometers. Temperatures of from 112° to 113° are not uncommon, and those of 108°–110° are exceedingly common.

There is no exact ratio between the frequency of the pulse and the height of the temperature in these severe forms of sunstroke. With a temperature of 110° the pulse may vary from 90°–150. The same is true when the temperature is 105°–106°. The number of respirations per minute may vary from 16 to 50, irrespective of the temperatures.

In the most severe cases death rarely occurs immediately, but is delayed for a few hours. It has been stated that when the temperature is reduced the patient is out of danger, although the elevation of temperature may persist for some days. This is by no means true. While it is true that consciousness returns in about half the cases within an hour after the reduction of the temperature to normal, and when once regained it is retained, others do not regain consciousness until after two or more baths are given to reduce the continually recurrent rise of temperature, and many patients may remain unconscious for twenty-four hours or even as long as ten days and yet recover. In the worst cases, even after the temperature has fallen, the patients do not react but die within twenty-four hours; some, however, will live longer and die without regaining consciousness at the end of a few days. Others, after they have regained consciousness and are apparently doing well, at the expiration of a few hours or one or two days may develop delirium and remain delirious for a few days or a week and recover, or they may die during the second period of delirium.

Patients with a temperature of 105°to107° frequently recover without thermic fever or any secondary rise of temperature. This exceptionally occurs when the initial temperature has been 107° to 110°. With temperatures above 110° there are one or more secondary rises of temperature which usually require active interference, or there is a continued fever for some time.

The secondary rises of temperature are apt to occur from three to six hours after the temperature has been reduced, sometimes not until from twelve to eighteen hours after the first bath. In serious cases the secondary rise may come on within an hour. It is not uncommon to find these secondary rises occurring eight, twenty-four, or thirty-six hours after the first bath. Some patients may have as many as four or five or even more exacerbations of temperature requiring active treatment. It is not uncommon to have thermic fever lasting for several days or one or two weeks, the temperature ranging between 101° and 103° F.

In severe cases after the bath the pulse remains feeble and soft and frequent. In favorable cases it drops more slowly to normal than the temperature. Among markedly alcoholic patients there is an asthenic course of the disease requiring special mention. The initial temperatures in these cases which have come under the writer's notice have varied between 106° and 109°, and the patients were strong, well-nourished individuals. They reacted well after their baths and became conscious within four hours, remaining rational for twenty-four hours; they then became wildly delirious or the delirium sank into the low muttering form. Their skin became dry and harsh, there was incontinence of urine and feces. During the wild delirium the temperature rose, frequently equalling in height the initial temperature, with a pulse of 120–150. In the low stage of the delirium the temperature did not rise above 102°, with a pulse of 80–100. In some patients just before death there was an antemortem rise of temperature to 106° to 110°. These patients died within *from three to eighteen* days after the sunstroke.

The convulsions mentioned as occurring in severe cases are not dependent upon the height of the temperature. They occur with temperatures of 105° to 106°, as well as with those of 108° to 112°, though they are more frequent with the higher temperatures; and since they seem to depend on the toxic destruction of the central ganglion cells, they are always of serious import though by no means fatal. They may be of a general epileptiform type, or they may be confined to the head, neck, arms, and legs. They may be more severe on one side of the body than on the other and rarely are distinctly unilateral.

While they may occur with the acme of temperature, they may not develop until some hours after the temperature has fallen. When the patient is in convulsion before the first bath the convulsions are apt to continue for some time afterward, though they may cease when the temperature becomes normal. Sometimes a second bath of a few minutes will cause them to cease. After they have disappeared and the patient has been rational for hours, or even one or two days, convulsions may suddenly recur and the patient may die in one. This is not uncommon. Muscular twitchings which do not develop into the convulsions are exceedingly common. An intense rigidity of the muscles similar to tetanic spasms is of quite frequent occurrence. This usually relaxes as the patient sleeps. These spasms may involve the respiratory muscles, and when they come on suddenly there is great danger of suffocation. The rigidity is often so great that artificial respiration is impossible.

The skin, in these cases of hyperpyrexia, often becomes dry and harsh during the week after the sunstroke, and desquamation may occur, the skin pealing off in large scales or flakes. Ecchymoses which occur in patients from bruising during the delirium are much more extensive than those occurring from ordinary

bruises, and hypodermic injections of any substance are not infrequently followed by large ecchymoses which may go on to suppuration.

Complications.—Meningitis and encephalitis are not uncommon complications of sunstroke. Delusional insanity, with ideas of persecution and hallucinations of various kinds, are frequently observed. Pneumonia sometimes develops and is usually fatal. Fayer mentions that cerebral hemorrhage may follow sunstroke. Patients with chronic nephritis are very apt to have acute exacerbations of the nephritis and develop acute uremia.

The sequelæ of sunstroke, even after the mildest forms, are often very pronounced. Not infrequently headache, extreme weakness, malaise, and dizziness are persistent. There may be soreness in the muscles and bones, with numbness and tingling of the hands and feet. This tingling may last for days or weeks, or even months. Anemia is usually very noticeable. Polyuria, glycosuria, or diabetes mellitus may develop shortly after sunstroke and be permanent. Chronic meningitis with intense headache and stiffening of the cervical muscles or encephalitis with incoordination of the extremities, so that the patients may be unable to feed themselves, have all been seen following sunstroke. The nervous and mental conditions may develop into permanent dementia. Various forms of insanity, such as paresis or mania or delusional insanity, are recorded. Multiple neuritis may develop. Sometimes atrophy of a certain group of muscles, as, for instance, the flexor muscles of the forearm, may occur. Patients may develop a change of disposition, and from good-natured become ugly and irritable in disposition. Sensitiveness to heat, dizziness, and headache are probably the most common sequelæ. Chromatopsia on hot days may occur. Epilepsy may arise, and when previously present the fits occur with increasing frequency. Loss of memory and inability to concentrate the mind forces some patients to give up their work.

Diagnosis.—Heat exhaustion may be confounded with internal hemorrhage, cardiac failure, and alcoholism. The intense headache of which the patient complains will aid in diagnosticating heat prostration. The moderately severe forms of insolation, especially with subnormal temperatures, restless delirium, and collapse, must be differentiated from internal hemorrhage and cardiac failure. The intensity of the delirium and twitching of the muscles will aid in recognizing the condition.

When unconsciousness is present the diagnosis from apoplexy, with its slow, full pulse, stertorous breathing, normal temperature, and local paralysis, can easily be made. In sunstroke we have a soft, frequent pulse, shallow breathing, and rise of temperature, and often hot, dry, flushed skin and absence of local paralysis.

The hyperpyrexial form may be confounded with meningitis, typhoid fever, and abscess of the brain with extremely high temperature. The usual excessive height of the temperature with the peculiar respirations, convulsive movements or intense convulsions, or the absolute immobility of the patient and the cool, clammy skin and high temperature, with the history of previous environment, should render the diagnosis easy.

Prognosis.—The prognosis of heat prostration is universally good. In the moderately severe forms of sunstroke it is also good. The prognosis of the severe forms depends on the previous habits and condition of the patient. In alcoholics and those weakened by disease the prognosis is worse than in those of abstemious habits. The height of the temperature usually serves as a good criterion. When the temperature reaches 111° F. or over, the prognosis is very unfavorable, though by no means hopeless. With a temperature between 110° and 111°, if proper treatment can be applied quickly, about 50 per cent. recover. If proper treatment is not applied, very few recover with a temperature above 108°. Temperatures between 108° and 110° under good treatment have 75 per cent. of recoveries. With temperatures of 105° to 108° about 90 per cent. recover. These statistics are based on the death rate in 1896 among 520 hyperpyrexial cases. The death rate in those treated by hydrotherapy in various ways was 25.12 per cent. In 805 cases of all forms the mortality was 16.39 per cent. The mortality is usually given as from 41 to 50 per cent. In 961 cases reported in Aiken's "System of Medicine," the mortality was given as from 56 to 62 per cent.

The mortality in sunstroke depends greatly upon the rapidity with which treatment is instituted and also on the kind of treatment employed.

Treatment.—In the milder forms of prostration, if the patient is overcome in the sun, he should be immediately taken into the shade and if possible to a cooler place. The clothing should be loosened and the head bathed with cold water. If possible, ice should be applied to the head; this gives great relief to the throbbing headache. Aromatic spirit of ammonia, Hoffman's anodyne, or liquor ammonii acetatis should be given for stimulation. A little alcohol, such as a small dose of whiskey, is sometimes of benefit, though it is by no means as good as the other forms of stimulants mentioned. Iced tea and coffee are also excellent remedies here. Sipping very cold water will also revive a patient overcome with a feeling of faintness. Some of the coal-tar products are also valuable here to relieve the headache, such as phenacetin, in gr. v. doses; antipyrin, gr. x. to xv.; or acetanilide, gr. iv.; If these can be mixed with a little sodium bicarbonate or caffeine they are excellent. The patient should rest, preferably in bed, for some hours until the feelings of faintness and dizziness have passed; he can then be allowed to go about as usual, being careful not to overexert himself and taking especial care to eat only easily digestible foods.

In the moderately severe forms, when collapse and subnormal temperature occur, the patient should be covered with blankets and hot-water bottles packed around the outside. The same stimulants may be given, and if the patient is unconscious hypodermic medication is necessary, gr. $\frac{1}{30}$ to $\frac{1}{60}$ of strychnine, gr. $\frac{1}{100}$ of glonoin, gtt. i. to ij. of fluid extract of digitalis, or gr. i. to ij. of a mixture containing ten per cent. camphor and ether can be administered. If the temperature is 103° or 104° and the patient is unconscious with convulsive twitchings, he should be placed in a cold pack, as a sheet wrung out of cold water, or put in a cold bath and vigorously rubbed for a few minutes, then dried and covered with blankets. If the temperature is not above 107° and is not relieved quickly, sometimes an enema of ice water acts with great benefit. One or two quarts of ice water, in which salt has been dissolved (one teaspoonful to the pint), will often, when used as an enema, bring the temperature down within an hour. But this ice-water enema will not control a rising curve of temperature. Headache in these cases can be controlled by the coal-tar products, which also aid in reducing the temperature, and by the ice cap.

The hyperpyrexial cases demand the most active and immediate treatment. Various forms of cold baths have been used. An ice bath consists of a tub of water in which about half a bushel of cracked ice is floating. Just before the patient is lowered into the bath the ice should be removed, as sometimes the sudden contact with the ice causes intense rigidity of the patient which brings on suffocation. This is rare, but it does occur; therefore the ice should be taken out of the bath before the patient is put in, but if the patient is put in ordinary tap water and rubbed a few moments, the ice can be placed in the bath while the patient is in it. During his stay in the bath the pa-

tient should be rubbed vigorously with rough mittens or the bare hand; sponges do not afford sufficient irritation; and as long as the patient is in the bath the rubbing should not cease. His head should be supported and cold water continually poured upon it. A towel folded over the forehead will prevent the water running into his eyes. Such a bath in a few minutes will cause the cyanotic skin of the patient to appear flushed and rosy; an unconscious patient may come to in the bath and the temperature will quickly fall toward normal. A thermometer should be constantly kept in the rectum of the patient in the bath, and the temperature should not be allowed to fall below 103° F. When this is reached the patient should be quickly taken from the water, rubbed dry, and covered up warmly. Hypodermic stimulation will be required in these patients. The ordinary results of this stimulation do not seem to occur while the temperature remains excessively high. This should be remembered, as overstimulation can easily be brought about, and this will occur when the temperature falls to a point near normal. For cardiac stimulation a dose of morphine, gr. $\frac{1}{8}$ to $\frac{1}{4}$, with gr. $\frac{1}{120}$ atropine, will be most beneficial. It diminishes the convulsions which are apt to follow and produces a sleep from which the patient wakes refreshed. Strychnine increases the tendency to convulsions, although it does not cause all the convulsions following sunstroke, as has been stated. Convulsions will occur in patients who have never had strychnine, but they do not appear so frequently as when strychnine has been used.

The length of time necessary for the reduction of temperature by these cold baths cannot be stated. It depends upon the amount of heat being produced, and not at all upon the height to which the temperature has gone. It may take twenty minutes to reduce a temperature from 106° to 103°, while a temperature of 110° may drop to 103° in five minutes.

Another method of reducing temperature is to place the patient on a rubber sheet and rub with ice. This takes much longer, it allows friction only of the upper surface of the body, and it does not reduce temperature so quickly or so effectively.

Still another method is to place the patient on a cot on a rubber sheet and throw dipperfuls of cold water over him from a distance of several feet. The impact of the water causes the necessary friction, and it is not an ineffective method. While it takes longer to reduce temperature, the reactions following it are not so marked as in the case of the ice bath, and when ice cannot be obtained it is the quickest substitute. While the water is being dashed over the body of the patient, cold water should be poured upon the middle of his forehead from a pitcher held six or eight feet above his head; this is most beneficial in bringing the patient back to consciousness. A very excellent method, perhaps the best, is to place the patient in a tub or on a cot or simply lay him on the floor and play a hose on him through a fine needle-spray nozzle. Where the head of water is sufficiently strong this is a most excellent method. It causes the physical irritation to the skin which is so essential to overcome the stasis in the capillaries. This stasis, according to Winternitz, prevents ninety-four per cent. of radiation of heat from the skin.

Patients treated in this manner should be allowed to have their temperatures fall to 102° or 101°; then they should be taken up, dried, blanketed, and put to bed. In severe cases the reaction following this method does not seem to be so intense as with the ice baths, nor so apt to fall below the normal. When the reaction occurs and the temperature goes to 105° the treatment should be repeated; an ordinary tub bath at 65° will sometimes control it. Warm baths have not proved so successful as the cold ones for reducing the temperature.

No treatment seems to prevent the thermic fever. A useful method of controlling this fever is to place small bladders filled with ice in the axillæ and groins; this seems more effective in women than in men.

After the patients are in bed, liquor ammonii acetatis is a most excellent stimulant and produces both diaphoresis and diuresis. Digitalis, ether, and spirit of ammonia are also excellent for rapid stimulation. Hypodermics of ergot assist greatly in sustaining the equilibrium of the circulation.

Among alcoholics the question arises as to the desirability of giving alcohol. When delirium tremens seems about to develop, as it so often does, a mixture of half an ounce of whiskey with one or two drachms of paraldehyde, repeated in an hour if necessary, will often produce sleep from which the patient will wake much improved.

It is best for twenty-four or forty-eight hours to keep the patient on milk, or at least fluid diet, followed by eggs, cereals, milk, and broth. When there is severe thirst an abundance of water should be given. The liquor ammonii acetatis is useful in this connection to allay thirst. The sequelæ or complications of sunstroke should be treated as the same diseases under ordinary circumstances. The nervousness, weakness, and loss of appetite can be overcome by a mixture of tincture of nux vomica and compound tincture of cinchona, five to ten drops each, in compound tincture of gentian as a menstruum. For alcoholics, one or two drops of capsicum and sometimes ginger can be added to this mixture. Meningitis following sunstroke may have to be treated by a merciless use of the actual cautery. Patients suffering from sunstroke in the tropics may have to go to a more temperate climate or they may become helpless invalids. Such patients may develop some form of insanity, and it is well to remember the possibility of suicidal tendencies and never allow them to travel alone. The anemia and general lack of nerve force following sunstroke can often be treated with cod-liver oil and small doses of tincture of iron. Of the latter, three drops should be put in a tumblerful of water and sipped with meals. This does not derange digestion and is preferable to large doses. Blaud's pills or any other form of iron may be used.

The numbness and tingling so often complained of can sometimes be benefited by the Charcot douche to the spine.

It is remarkable how long the sequelæ of sunstroke may persist, and they are often discouraging to deal with. It may be years before exposure to heat can be withstood without recurrent headache and prostration.

ALEXANDER LAMBERT.

Hebephrenia.—That the years from puberty to full maturity (fifteen to twenty-five) are a period of danger for the mental balance in the youth of both sexes, has long been known, and a form of mental disease specially frequent at this period, in the older textbooks (Clouston, Griessinger) finds mention under the name of "Insanity of Adolescence." For its first accurate description, as well as for the name "Hebephrenia" (ἥβη youth, puberty, φρήν, mind) we are indebted to Hecker, who gave its most important characters as outbreak at the time of puberty, successive or alternating occurrence of melancholia, mania, and confusion with rapid progress to mental deterioration and termination in a dementia, characteristics of which are recognizable even in the early stages of the disease. The name has now become firmly attached to one of the forms of dementia precox which Kraepelin describes as beginning usually as a subacute, more rarely as an acute mental disturbance and in which a simple more or less profound dementia developes.

ETIOLOGY.—The causes of hebephrenia are those of dementia precox in general (*q.v.* under *Mental Diseases*).

SYMPTOMS.—Hebephrenia begins in general about

the time of puberty (from twelve to eighteen years) usually so gradually that the exact time of its onset can scarcely be determined; in fact, recent investigations make it seem probable that the roots of the disease may reach back even into childhood and that certain evidences of mental weakness appearing even at a tender age may be attached to this disease, while "formes frustes" are probably more common than is supposed, since its manifestations are individually little different from those which when of fleeting occurrence may be within the bounds of the normal during adolescence.

Stanley Hall has in fact declared, that he has seen all the symptoms usually attached to dementia precox at one time or another occur, in youth "who have later developed to sound and efficient maturity." Many cases never come into the hands of an alienist at all, since the halt in previously normal development is often attributed to some illness or other fortuitous circumstance, or to defects of character.

The chief psychical symptoms are, tendency to fantastic unclear impulsions, an exaggerated feeling of self, tendency to busy oneself with deep world problems, preference for high-sounding phrases, a tendency to coin new words and to speak in a pompous manner, to perpetrate shallow witticisms or to play foolish jokes, the picture altogether being one of childishness, silliness, and youthful folly in unattractive form. Sense of time and place are little disturbed at the start, ability to note and receive impressions and memory are scarcely affected, while the mental processes suffer an alteration which Kraepelin has styled "dissolution of thought," manifested by increased distractibility, loss of the internal relations of conceptions, with tendency to the sudden irruption of interpolations. Power to form judgments fails and there may be delusional ideas, which are apt to be of little permanence and often of abstruse content, usually without corresponding emotional tone. There is dulling of feeling and affective life, shown by indifference to family relations, with failure of ethical sense and respect for social usages. There is great lability of mood, the patient often passing within a short period from happy extravagance to deep depression. Spontaneous merry excitement with signs of intellectual failure and the special peculiarities of puberty give an appearance of peculiar silliness and foolishness.

It is usual that for a long time the friends cannot understand the meaning of inability to continue upon what may have been a promising career and are apt to attribute it either to laziness, indifference, and ill will or to physical causes, especially to masturbation which is commonly an effect, not a cause, of the disease, or in females, to the changes incident to puberty. The experienced physician, however, may detect increased fatiguability and abstractability, inability to concentrate the mind and to form decisions, defect in judgment-forming capacity and dulling of the higher feelings. At the start most of these patients have a sense of their disability and complain of a feeling of pressure or of emptiness in the head, spots before their eyes, dizziness and depression, and very likely sleep poorly. Again, they are dull and indifferent and meet reproaches with empty answers or with sullen obstinacy. Tasks are begun but never finished; the patient may sit for hours, pencil in hand, before a sheet of paper and write nothing; he will not wash or dress, lies around on the floor or refuses to get out of bed. It may be thought at the start that his occupation is unsuitable, but change of employment brings no increase in efficiency.

Other cases present a state of increased excitement and unrest, plunge into alcoholic and sexual excesses, engage in foolish quarrels, make absurd demands or essay to fit themselves for great rôles which they are to play, as actors, playwrights, singers, or what not. Others again, fall into a condition of hypochondriacal depression and accuse their former excesses, particularly masturbation, as the cause of their steady mental failure. Even in these cases of slow and quiet onset, however, the progress is not steady, but remissions may vary with accentuations of activity.

Still another set of cases begins suddenly and stormily under the picture of various psychoses with depression or excitement, sleeplessness, anxiety, self-accusation, perhaps suicidal attempts, hallucinations and illusions of the most varied sort, also delusions, especially those of being poisoned, of electricity being applied, of being abused sexually, etc. These patients may be dangerous to themselves and to others as they are likely to make sudden assaults or to commit self-mutilation or suicide. Throughout the whole, however, there is the picture of mental dullness, lack of natural emotion and steady intellectual deterioration, which may be broken by episodes of confusion and excitement with sudden violent acts. Again some cases begin with symptoms resembling those of mania or amentia while ideas of grandeur may complicate the picture, though careful observation may still detect the characteristic traits of juvenile dementia.

The physical symptoms of hebephrenia, which are hardly characteristic, are disturbed sleep, sudden and great fluctuations in weight, disturbance of the sweat and sebaceous secretions, irregularities in menstruation, fibrillary contractions, changes in the pupillary phenomena (see catatonia), insensibility of the nerve trunks, etc.

Since hebephrenia is but one of the varieties of dementia precox and shades by imperceptible degrees into the other forms, it is but natural that some of the symptoms of these are not infrequently present, though in imperfect development, so that we may have indications of negativism, and stereotypy and of partially systematized delusions. Our diagnosis of which form of dementia precox we have before us, must depend upon which traits preponderate as a whole.

Diagnosis.—Our diagnosis of hebephrenia must depend in the main upon the grouping of the symptoms noted above as characteristic and especially upon the progressive mental failure with its general character of childishness and silliness. Many of these cases at the start are taken for neurasthenia. In hebephrenia none of the causes of exhaustion which produce neurasthenia can be found, it fails to yield to treatment as neurasthenia does, and the characteristic mental failure is soon unmistakeable. In all neurotic disturbances in youth, the possibility of dementia precox should be kept in mind.

From acute confusion (amentia) the diagnosis may be difficult at the start, but the causes of this disease are lacking in hebephrenia; in amentia the physical exhaustion is unmistakeable, confusion and disorientation dominate the picture, while there is labile play of emotions in contradistinction to the dullness and indifference of the hebephrenic.

Mania and melancholia do not show the signs of mental deterioration present in hebephrenia, the flight of ideas expressed in the former shows a more definite connection between the words uttered than those emitted by the disturbed hebephrenic, while in the latter there is mental retardation, not inhibition, as in dementia precox. Still, in a first attack, the manic-depressive psychosis may be difficult to differentiate at the start from hebephrenia.

Prognosis.—The prognosis of hebephrenia is quite unfavorable. Kraepelin's statistics give in only eight per cent. of the cases apparent recovery, in seventeen per cent. moderate dementia, and in seventy-five per cent. profound dementia, as a termination. As in dementia precox in general, the recoveries are relative only since the patient will nearly always be found to have descended to a lower level mentally

and to have become unfitted for the higher grades of employment.

Treatment.—Specific treatment of hebephrenia there is none, the question being chiefly what is to be done with the patient, whether or not he must be sent to an asylum. In the early stages every effort should be made to check the disease, while regulating the patient's habits, by taking him away from unsuitable employment and by providing for rest in a quiet location, best in the country. There should of course be treatment of any existing physical disease, while suitable hydrotherapy and tonics may be of benefit. After the morbid symptoms have become modified or have disappeared, the finding of suitable occupation for the patient, who has probably descended to a lower mental plane, will require some thought, and in all plans for him the possibility of a new exacerbation of the disease which is very likely only quiescent, must be taken into consideration.

Charles Lewis Allen.

Heberden, William.—Born in London in 1710. He received his academic instruction in the University of Cambridge, England (1724 to 1730), and soon afterward began the study of medicine, part of the time in the latter city and subsequently in London. After he had received the degree of Doctor of Medicine he spent the following ten years of his life in Cambridge, in the practice of his profession. In 1748 he established himself in London, and was elected a member of the Royal Society. For over thirty years he was one of the best known practitioners in that city. He died in 1801, at the advanced age of over ninety.

Fig. 3115.—William Heberden

Heberden's work, "Commentaries on the History and Treatment of Diseases" (published in London in 1802), was written by him when he was seventy-two years old. Its great practical value depends upon two facts: first, that the author was a keen observer and, second, that it was his unfailing rule, during the long years of his practice, to keep a careful record of every case that passed through his hands. Furthermore, he arranged the different data of this record in such a manner that no difficulty would be experienced in ascertaining from it the precise nature and behavior of the malady in each case and the action of the drugs or other remedial measures which he employed. His own comments were based entirely upon this rich mine of facts actually observed by himself, and at no time did he permit himself to complete any of these data by quoting facts reported by other observers. He was the first to describe varicella and angina pectoris (long known as "Heberden's asthma"), and his name is still attached to the exostoses on the terminal phalanges—"Heberden's nodes."

A. H. B.

Hebosteotomy.—*Definition.*—An obstetrical operation, performed solely in the interest of the child, in which the pubic bone of the mother is divided, with the object of temporarily enlarging the pelvis.

History.—In a paper read in Strasburg, in 1844, Lacour mentions that his teacher Stolz advised enlarging the pelvis by sawing through the pubic bone at one side of the symphysis, and demonstrated his method on the dead subject. We then heard nothing further of this operation, now variously called hebosteotomy, hebotomy, pubiotomy, pubotomy, until Gigli, in 1894, again proposed it, believing that it would do away with the disadvantages of symphyseotomy, while retaining all its advantages. Bonardi was the first who performed hebosteotomy, as suggested by Gigli, on the living. Less than ten years ago Bumm and Doederlein simplified the technique, after which the operation became more popular. In Europe, hebosteotomy reached the height of its popularity in 1907; in America, previous to that year, but few obstetricians took it up, among those who did were Montgomery, Norris, and Bill. After 1907, it was performed more frequently in this country, finding among its most ardent supporters W. Williams. On the whole however the number performed the world over since 1907 has gradually diminished, as will be seen from the table below. It is safe to say that all operators who performed many hebosteotomies six years ago, perform fewer to-day. The reason for this change was natural, only after a considerable number were performed were we in a position to judge correctly the maternal and fetal mortality, and learn to know the dangers connected with the operation, all of which were greater than we anticipated and consequently the indications were narrowed down and fewer were performed. Another reason for the decrease is that to-day the extra- and transperitoneal cesarean sections are on trial in those cases in which hebosteotomies were formerly performed. It is not obsolete, it still has some, but few indications.

In 1902 the results of 5 hebosteotomies were published
In 1903 the results of 9 hebosteotomies were published.
In 1904 the results of 14 hebosteotomies were published.
In 1905 the results of 31 hebosteotomies were published.
In 1906 the results of 129 hebosteotomies were published.
In 1907 the results of 352 hebosteotomies were published.
In 1908 the results of 160 hebosteotomies were published.
In 1909 / In 1910 } the results of 300 hebosteotomies were published.
In 1911, 1912, and 1913 still fewer.

Operative Technique.—While there have been numerous minor modifications at all times, the technique may be classified under three heads:

1. *The Open Method.*—Gigli made an oblique incision through the skin over the anterior surface of the pubes, beginning just to the side of the symphysis and running downward and outward to the tuberculum subpubicum at the outer border of the labium majus. A carrier was then inserted from above downward behind and close to the pubic bone in a line parallel to the skin incision; to this a Gigli saw was attached and drawn through behind the bone, when the latter was divided. Van der Velde modified the operation by beginning his incision at the superior pubic spine and carrying it obliquely downward and inward until he reached the labium majus at the level of the vestibulum; he then proceeded as Gigli, dividing the bone parallel to the skin incision. He claimed the obturator foramen would be less likely to be injured by this method.

2. *The Partly Subcutaneous Method.*—Doederlein made a small incision along the upper border of the pubes, just internal to the spine, going through the skin and the insertion of the rectus, and large enough to enable him to insert one finger behind the bone with which the bladder and retropubic tissue could be pushed away, thus making way for a carrier which he passed vertically from above downward, close to the bone, with the finger as a guide. The carrier is brought through the labium majus below, the saw is attached and pulled up behind the bone, which is then divided from behind forward. The upper and lower wounds are then closed by suture.

3. *The Strictly Subcutaneous Method.*—Bumm makes no incision at all, but uses a sharp-pointed carrier

which he inserts two centimeters from the median line, carrying the instrument from below upward, closely hugging the lower border and posterior surface of the bone, under the guidance of two fingers in the vagina. The carrier reappears two centimeters from the median line just inside the pubic spine. To it the Gigli saw is attached and drawn behind the bone, the latter then being divided from behind forward.

No matter which method is employed, the patient is prepared for operation, and is placed in the lithotomy position. The bladder must always be emptied, and if a metal catheter can be used it may be possible to tell just to which side the bladder is drawn. The bone should be divided just internal to the pubic spine, but as the latter can often not be felt, it is a good rule to divide it two centimeters from the median line. The labium majus should always be pulled well toward the median line and held there, so that when released the skin wound will not come directly opposite the bone wound. While passing the carrier the head should be pushed up as much as possible by the vaginal finger. This maneuver is facilitated by the Trendelenburg position; if the abdomen is pendulous, the abdominal wall should be pulled up, both precautions to avoid injuring the bladder. The arc in which the saw is held should be from 120 to 150 degrees, as it is liable to break if held at a sharper angle; even so, it is wise to have at least three saws ready for use. When the bone has been divided the amount of separation must be watched, the assistants steadying the pelvis from either side, while the operator judges the amount of separation with the finger in the vagina. The separation should not exceed six centimeters on account of possible injury to the sacroiliac joints. It matters little whether the bone is divided on the side of the fetal occiput or not, the left side being usually selected as it is most convenient for the operator. Any bleeding after sawing should be controlled at once, pressure from within and without the vagina usually sufficing. At this stage there are as a rule no tears, as the bones are not permitted to separate suddenly. If during delivery, be it operative or spontaneous, one suspect a large anterior vaginal tear, it is well to insert a rubber catheter into the urethra, as the latter is sometimes hard to find during the repair of the rent. If the delivery is operative, version and forceps have given equally good results. No matter which, it is well to remember to pull down in the axis of the birth canal and to deliver slowly; on a hebosteotomized patient failure to do this will be accompanied by much greater injury than under ordinary circumstances. Vaginal tears will be greater than they should be if we pull forward too soon and deliver too rapidly. Immediately after delivery, whether spontaneous or operative, the bladder should be catheterized and if bloody urine is not obtained the viscus is probably not injured; on the other hand bloody urine does not necessarily mean a fistula, as it may be caused by contusion of the tissues; nevertheless if the urine is bloody, a permanent catheter should be left in place. After delivery all tears should be repaired, if the vaginal tear communicate with the bone wound we preferably drain. Whether tears occur or not, gauze should be packed into the vagina and over the pubes externally, this pressure acting as a prophylactic against hematomata. When a second hebosteotomy is to be performed on the same patient at a future pregnancy, it is best not to divide the same side as the scar and adhesions might become troublesome.

Choice of Operation.—The open operations of Gigli and Van der Velde were not a very great improvement on symphyseotomy, since the great danger common to both lies in the large, easily infected wound. This method has practically been abandoned. As regards the relative merits of the Bumm and Doederlein methods, it may be said that Bumm's operation is preferable if the genital tract is already infected, there being less of a wound and, therefore, less opportunity for further infection. In the Doederlein operation there is less danger of injuring the bladder, it is the one usually performed, and must be the one of choice when the head is engaged and presses the bladder against the pubes, or when we have reason to suspect a bladder adherent to the pubes as we sometimes find it after old pelvic inflammations, or when large arteries are felt on the posterior surface of the pubes. Out of 257 hebosteotomies published in 1909 and 1910, 160 were operated according to Doederlein, 45 according to Bumm, 25 according to Gigli, and 27 according to other methods. Among the 45 operated upon according to Bumm, there were 5 bladder injuries (11 per cent.), among the 160 according to Doederlein, there were 3 bladder injuries (1.8 per cent.). This readily proves the advantage of the latter method.

Immediate or Delayed Delivery after the Bone is Divided.—Obstetricians are still divided on this point. Many favor waiting, while such men as Schauta, Doederlein, W. Williams, and others prefer immediate delivery. The fact of the matter is, that the question as to which course should be followed depends entirely upon the conditions at hand, or rather upon the indications layed down by the operator for hebosteotomy. If the condition of the baby is already poor when the operation is being performed, there is no doubt that immediate delivery is best, as hebosteotomy is done solely in the interest of the child. If on the other hand the condition of the child is good at the time of the operation, the mother will run less risk of tears if we wait, especially if she is a primipara, and this even though the woman must finally be delivered by forceps, since the later the latter is performed, the less the danger of tears. Therefore the operator whose indications have been narrowed down that he only performs hebosteotomy when the child is still in good condition will usually do best to wait, especially if his patient is a primipara. On the other hand the operator who performs them when the baby is already in danger, must go ahead at once. The writer believes that the indications should be so tightly drawn, that hebosteotomies should never be performed when the child is already in danger and consequently is a firm believer in giving nature a chance after the bone has been divided, even if he must later finish the delivery by forceps, especially since labor is not made more painful after hebosteotomy.

Accidents Caused by the Operation.—*Immediate.*—Hemorrhage.—This may cause immediate death or result in the production of a hematoma. A severe hemorrhage might be caused when there is an extensive anastomosis between the branches of the obturator and epigastric arteries, it can be avoided if we operate according to Doederlein. Again when the obturator foramen is injured the vessels running through it are injured, an accident which can be avoided by dividing the pubes internal to the tubercle, as the foramen never extends internal to it. Bleeding is usually external, nevertheless it must be remembered that cases have been reported in which the hemorrhage was retroperitoneal, extending right up to the kidney. The usual unavoidable source of hemorrhage is the crus of the corpus cavernosum, this being injured by the carrier, saw, or during the separation of the bones; this is rarely alarming and can be controlled by pressure. Hematomata can often be avoided by gauze packing in the vagina and external above the pubes after delivery.

Vaginal Tears.—These may or may not communicate with the bone wound. Both can often be avoided if we never operate upon primipara and never deliver immediately after dividing the bone.

Bladder Injuries.—These are less liable to occur, as we have shown above if we operate according to

Doederlein. They are also less frequent, if we avoid primipara and immediate delivery after the bone is divided.

Death of Mother and Baby.—The former may be prevented by avoiding hemorrhage, the latter by not operating when the child is already in poor condition.

During the Puerperium.—Fever.—This is to be prevented by avoiding the formation of hematomata, and vaginal and bladder tears. The same is to be said of thrombophlebitis.

The death of the mother may be avoided to a degree by preventing hematomata, vaginal, and bladder tears. The death of the baby is avoided by not operating when the baby's condition is already impaired.

Late After-effects.—Hernia between the bone-ends and also rectocele and cystocele may be prevented by avoiding the production of hematomata, vaginal and bladder tears. Sacroiliac pain is avoided by not permitting more than six centimeters separation of the bone.

Pelvic Changes Immediately after Operation.—Sellheim, Kroemer, and Tandler have demonstrated upon the dead subject, that the amount of room gained is the same as after symphyseotomy and that both sides of the pelvis are equally enlarged. Others hold that the side upon which the operation is performed is enlarged a little more than the other. Three centimeters separation of the bone causes the true conjugate to increase one centimeter and the transverse diameter at the brim one and a half centimeters, the outlet being enlarged to a much less degree. Four centimeters separation of the bones does not affect the sacroiliac joint, while six centimeters does. The latter degree of separation will not be so likely to do this in the living pregnant woman, as the joints are more movable than in the cadaver. The smaller the pelvis the greater the danger for the sacroiliac joints.

After-treatment.—This is simple, the patient is kept on her back a few days, an ordinary abdominal binder extending half way down the thighs is sufficient support for the pelvis. The old rubber bandage and special apparatus has been abandoned, even the adhesive straps around the pevis used by some are not necessary, though possibly a source of comfort to the patient. In fact, any special apparatus is considered detrimental, the separation of the sawed ends being considered favorable to a permanent enlargement. The patients are kept in bed from eighteen to twenty-one days. The bone ends are then firmly enough united to permit walking, one certainly does not have to wait until fragments no longer move on each other, as mobility is often permanent. As regards the mode of ascertaining mobility; if done while the patient is in bed it will often prove misleading, the only way to examine for mobility is to have the finger of one hand in the vagina at the lower bone wound and the finger of the other hand external at the upper bone wound while the patient is standing, and then to have her move from side to side, first throwing her weight on one leg and one half of the pelvis, and then on the other leg and the other half of the pelvis. If a catheter was inserted and there is no fistula, it is removed in seven days at the latest. A urinary fistula is treated in the usual way. The vaginal gauze is removed at the end of twenty-four hours.

Mode of Healing of the Bone Wound.—When mobility between the fragments exists, and at times this persists permanently without interference with function, there is no doubt that the union is fibrous and not bony. When a firm callus is felt, function is good, and movement of the cut ends is absent, many observers have thought the union was bony. While the latter might be so occasionally, the majority of *x*-ray pictures, taken six months after hebosteotomy, show a light spot between the cut bony ends, from which we must conclude that the callus is not bony and furthermore will not become bony, for it is well known that there never will be a bony union of a fracture if it has not set in within six months after the bone was broken. Such *x*-ray findings have been substantiated histologically and chemically on the human being, and by Offergeld and Sellheim, who experimented on animals. They found that microscopically the callus consisted only of connective tissue and cartilage, while the chemical examination showed nine-tenths organic and one-tenth inorganic matter, there being practically no inorganic matter as compared to normal bone. The latter contains two-thirds inorganic matter. They found the consistency varied with the amount of inorganic matter. Osteoblasts were always absent. Other *x*-ray pictures showed a dark spot at the point of the callus, but even these have been shown not to be proof positive that the callus was bony, for some of them, when examined after the death of the patient, were found to be mainly fibrous, being covered only by a thin shell of bone.

Kannengiesser reported eighteen cases with enlargement of the true conjugate of from one-half to one and a half centimeters. Van der Velde collected 124 cases from the literature with seventy-four permanent enlargements. In Heidelberg twenty-one patients were followed up, only one showed an enlargement and four actually were smaller than before. We thus see that reports vary. It is well to remember that *x*-ray photographs of pelvic diameters have been proven less reliable in ascertaining their size than the ordinary modes of examination. The course of future labors will depend upon: (1) the size of the future child's head; (2) the hardness (mouldability) of the head; (3) whether the pelvis has been permanently enlarged; (4) whether it has remained the same size but enlarges during the subsequent pregnancy due to softening of the callus; (5) whether it remains the same size and the callus does not soften during the subsequent pregnancy; (6) whether the pelvic inlet has been made smaller due to the callus projecting into the pelvic cavity. Out of 137 hebosteotomized women who subsequently became pregnant, ninety-three were delivered by forceps, version, or spontaneously; twenty-eight by a second hebosteotomy; sixteen by abdominal cesarean section. Such statistics on the result of a future labor, without pelvic measurements immediately after and before the first hebosteotomy, and without head measurements and some knowledge of the mouldability of both heads, mean nothing in favor or against the original hebosteotomy. The fact remains that many patients come to a second hebosteotomy, others to cesarean section, others to premature induction, and still others to normal labors. The reports on pelvic measurements, before and after hebosteotomy, and the course of future labors are so variable, that possible permanent enlargement should not play a rôle in deciding whether a hebosteotomy should be performed in a given case. We cannot promise permanent enlargement, small and mouldable head in the future baby, or normal future labors.

Prognosis.—This in any operation will depend greatly upon the skill, indications, and contraindications of the individual operator, in other words upon the number of possible accidents we can meet and the frequency with which they occur. Large statistics including the results of operating skill of varying character differ from the reports of individual operators. Both will again differ, depending upon whether the indications were broad or narrow. Those who only operate upon clean cases and do not deliver at once after the division of the bone, will get better results in the mothers, while those who operate only when the baby is in good condition, will get better results in the babies.

The first two tables below show statistics, compiled by Schlaefli in 1909, on 700 hebosteotomies performed by different operators whose indications and contra-

indications varied, and a similar table by Roemer in 1911, on 300 cases published in the literature after Schlaefli.

Complications.	Previous to 1909		1909 and 1910.	
	Cases.	Per cent.	Cases.	Per cent.
Marked hemorrhage	510	15.3	228	15.4
Death due to hem	644	0.3	300	0.33
Hematomata	510	17.1	228	14
Vaginal tears communicating with bone wound.	510	15.5	228	7
Simple vaginal tears	510	17.84	228	3.9
Bladder injuries	510	12.35	228	5.2
Fever	510	31.76	228	20.6
Thrombophlebitis	510	8.2	228	3.5

Mortality Previous to 1909.

	Per cent.
Among 510 mothers	4.96
Due to operation alone	4.37
Among 510 babies	9.6
Due to operation alone	9.18

Mortality in 1909 and 1910.

	Per cent.
Among 300 mothers	2.66
Due to operation alone	1.7
Among 300 babies	6.66
Due to operation alone	5

We thus see that in the recent cases, while the hemorrhage was the same, thrombophlebitis, fever, bladder injuries, simple vaginal tears, communicating vaginal tears with the bone wound (these are important since they are followed by death in from six to twelve per cent. of the cases), mortality of mother and child have all diminished. This improvement is undoubtedly due to the fact that the indications have been narrowed down and that the operations have been more skillfully performed.

Statistics of individual operators (who have performed more than twenty-five hebosteotomies) with varied indications and contraindications, show better results as regards the mothers (mortality of from 0 to 2 per cent.) while their results in children, in whose interest the operation is performed, are no better, in many instances worse.

The following table comprises hebosteotomies by different operators, but classified as to whether they were performed on primipara or multipara:

Previous to 1909.	In 1909 and 1910.
Of 126 primipara 32.5 per cent. had vaginal tears communicating with bone.	Of 25 primipara 20 per cent. had vaginal tears communicating with bone.
Of 320 multipara only 11.9 per cent.	Of 203 multipara only 5.4 per cent.

Showing an improvement in recent years, but also that the operation is more dangerous in primipara at all times. It indicates that the proportion of primipara to multipara operated upon in recent years, has decidedly diminished.

The following table comprises hebosteotomies by different operators, but classified into clean cases and doubtfully clean cases, *i.e.* in which some other mode of delivery had first been attempted.

Thirty-nine clean cases—no deaths in mother—10 per cent. in babies.
Fourteen doubtful cases—21.5 per cent. deaths—in mothers—56.25 per cent. in babies.

Showing that clean cases give better results in mothers and that cases in which the baby's condition is already impaired, the mortality is high for the children.

Indications and Contraindications.—These have always differed among the various operators. They all agree that the inlet and outlet of the pelvis must not be too small. While the vaginal examination need not show that the largest circumference of the head is through the bony inlet, it should, however, give one the impression that the largest circumference will easily enter the inlet after hebosteotomy. They all agree that the size of the true conjugate must not be below a certain figure, they differ, however, as to what this figure should be. Indeed the figure should vary with the same operator, for much depends upon the size and mouldability of the baby's head. In a flat pelvis the low mark varies from 6.5 to 7.5 centimeters, in a generally contracted pelvis from 7.5 to 8 centimeters. Hebosteotomies are, therefore, indicated in moderately contracted pelves with dystocia, be the inlet or outlet at fault. When the latter is the cause of the trouble, hebosteotomy is especially serviceable in persistent mento-posterior positions.

This first condition, *i.e.* not too great a disproportion between bony pelvis and head, fulfilled, the following are the conditions under which the operation is possible:

1. Baby O.K. Primipara. Clean case.
2. Baby O.K. Primipara. Infection doubtful.
3. Baby O.K. Primipara. Infected case.
4. Baby O.K. Multipara. Clean case.
5. Baby O.K. Multipara. Infection doubtful.
6. Baby O.K. Multipara. Infected case.

7. Baby impaired. Primipara. Clean case.
8. Baby impaired. Primipara. Infection doubtful.
9. Baby impaired. Primipara. Infected case.
10. Baby impaired. Multipara. Clean case.
11. Baby impaired. Multipara. Infection doubtful.
12. Baby impaired. Multipara. Infected case.

The operator with the broadest possible indications would perform a hebosteotomy under any of the above twelve conditions. The chief points operators differ on are:

1. Whether the operation should be performed only when the baby's condition is good, or whether it still may be performed when the baby is already impaired.
2. Whether the operation should be performed only upon multipara or also on primipara.
3. Whether it should be performed only in clean cases, or also in doubtfully, and surely infected cases. By clean cases we mean those in which there is no fever, no foul discharge, no rupture of the membranes, and in which no examinations with doubtful asepsis have been made. By doubtful cases we mean those in which there is no fever, no foul discharge, in which the membranes have been ruptured some time, or in which there is nothing known about the asepsis of previous examinations. By infected cases we mean those in which there is fever, or foul discharge, or a positive history of non-aseptic examinations.

Under prognosis it has been shown that more than fifty per cent. of the children are still-born, if they were already impaired before the operation was begun. The writer believes that the operation should never be performed when the baby's condition is already impaired.

Under prognosis it has been shown that at all times primipara fared worse than multipara, and that in the last few years, during which the results of the operation have improved, the proportion of primipara operated upon, as compared to multipara, has decidedly diminished. It must also be added that, as a rule, delivery is harder on the child in a primipara than in a multipara. The writer believes that, as a general rule hebosteotomy should not be performed in primiparæ. Under special conditions may be permitted in old primipara whose age makes the possibility of becoming pregnant again doubtful. If performed in primiparæ, the operator should have had experience

with the operation and the family should be apprised of the dangers.

As regards clean, doubtfully infected, and surely infected cases, it stands to reason that the clean cases will fare best and that the doubtful ones will fare better than the infected ones. The writer believes that in clean cases, both baby and mother fare better if delivered by classical cesarean section. In doubtful cases (as defined above) hebosteotomy is indicated, but has as its competitor extra- and transverse peritoneal cesarean, and possibly also the suprapubic and classical intraperitoneal cesarean section. In surely infected cases it has as its competitor extra- and transverse peritoneal cesarean section. However, the results obtained in surely infected mothers with the three last-mentioned operations do not warrant any of them; the writer prefers embryotomy on the living child or an attempt, though apparently hopeless, at forceps or version. Several operations have just been mentioned as competitors of hebosteotomy, we should add that symphyseotomy, open or subcutaneous, gives, if anything, worse results than hebosteotomy. Induction of premature labor is also not a competitor, for at a time when it is indicated, hebosteotomy does not come into question.

I would therefore narrow the above twelve indications down to two, after the first requisite has been fulfilled, *i.e.* not too great a disproportion between head and bony inlet or outlet.

1. Baby not impaired; mother multipara, infection doubtful. Especially when the dystocia is due to a a contracted outlet accompanied by a persistent mentoposterior position.

2. In rare instances, baby not impaired, mother primipara, infection doubtful.

We thus see that hebosteotomy is an operation, which at one time had wide indications which to-day have been considerably narrowed. The decision as to whether it is indicated in a given case and the performing of the operation should be left to a man with wide obstetrical experience and operative training. The question whether the operation can be performed in the home, depends entirely upon the possibility of being able to obtain the proper assistance.

C. Frederic Jellinghaus.

von Hebra, Ferdinand.—Born at Brünn, Austria, September 7, 1816. He pursued his medical studies at the Universities of Gratz and Vienna, and received his doctor's degree from the latter institution in 1841. While he was acting as one of Prof. Skoda's assistants, his chief, observing the interest which he appeared to take in this class of patients, assigned to his special care all the cases of skin disease that came to his clinic. This was the very beginning of Hebra's work in dermatology. From this time onward he devoted a large part of his time and interest to the study of skin affections, and finally succeeded in placing this branch of pathology on such a firm footing that it was decided to establish a separate department for skin diseases in the Allgemeines Krankenhaus, the great hospital of Vienna, and to entrust the management of it to Hebra. This was in 1845. In 1848 he was made a physician of the first Rank in the Allgemeines Krankenhaus; in 1849 he was elected Professor Extraordinary, and in 1869 full Professor of Dermatology. He died August 5, 1880.

Hebra was strongly opposed to the prevailing view with regard to the constitutional origin of skin diseases, and maintained that they owed their origin to a greater or lesser degree to local causes. He also, following Rokitansky's systematic method of nomenclature, cast aside the prevailing humoralistic names given to skin diseases, and introduced a terminology which harmonized with the actual pathological conditions and with the facts which had been ascertained experimentally. Hebra was a most helpful instructor, and oftentimes his lectures were quite humorous. His audiences were composed of medical men who came from every quarter of the globe to listen to his teaching.

Aside from numerous shorter articles which he contributed to current medical literature, Hebra published the following larger works: "Versuch einer auf pathologische Anatomie gegründeten Einteilung der Hautkrankheiten," 1845; "Atlas der Hautkrankheiten, 1856–1876 (in association with Elfinger and Heitzmann); and "Acute Exantheme von Hautkrankheiten."

Pagel (*Biographisches Lexikon*), in summing up his estimate of the work done by Hebra, says that he was the head of modern dermatology in the same sense that Albrecht von Graefe was the chief of modern ophthalmology. A. H. B

Hectargyre is a combination of hectine with oxycyanide of mercury, and is used hypodermically as an alternative for *hectine* (*q.v.*) in the treatment of syphilis. R. J. E. S.

Hectine is an organic preparation of arsenic, which has been used recently in the treatment of syphilis. Chemically, it is benzol-sulphone-para-amido-phenyl arsenate of sodium, and was introduced by Mouneyrat in 1908. It is applied locally as a solution or an ointment or as a dusting powder; it is administered internally in the form of pills or a solution; it is also injected subcutaneously. In the latter form, about one c.c. of a $\frac{1}{10}$ per cent. solution is used. There seems to be decided difference of opinion as to the value of this preparation. Some observers claim that hectine has a rapid, curative action on syphilis, and that it is a comparatively safe remedy; others are not satisfied with the results that they have obtained.

R. J. E. Scott.

Hedeoma.—American or Mock Pennyroyal. "The dried leaves and flowering tops of *Hedeoma pulegioides* (L.), Pers. (*Mentha pulegioides* L.; fam., *Labiatæ*)." U. S. P.

This is a slender annual herb, very abundant in dry, especially rocky meadows and pastures throughout Eastern and Central North America. The base of the stem is frequently decumbent. The upper portion is usually much branched, the branches slender, erect or ascending, and quadrangular, the leaves opposite, slenderly petioled; blades usually less than 2.5 cm. (1 in.), long, and 1 cm. ($\frac{3}{8}$ in.) broad, oblong ovate, narrowed gradually into the petiole, obtuse, distantly and shallowly serrate, pale or grayish-green, thin, with few, strongly ascending secondary veins, and the lower surfaces beset with small, circular, depressed glands, which are usually golden-yellow and shining under a strong lens; flowers several in a leaf axil, pedicelled, the calyx tube cylindraceous, somewhat contracted at the mouth, strongly nerved, its tube two-lipped and slenderly and sharply five-toothed; corolla tubular, two-lipped, pale blue, spotted; stamens four, two of them sterile; odor strong, somewhat mint-like; taste aromatic and pungent.

With a little tannin and bitter extractive it contains nearly one per cent. of a volatile oil, official under the title *Oleum Hedeomæ*, which is its active portion.

American pennyroyal possesses the carminative, aromatic, and diffusive stimulant properties of the mints in general, and is similarly employed There is no official preparation, but an infusion is probably the best form of administration. One of the important properties of this plant and of its oil is that of repelling mosquitos to a considerable and useful extent.

Oil of pennyroyal is thus described: A pale yellow-

ish, limpid liquid, having a characteristic, pungent, mint-like odor and taste. Specific gravity, 0.930–0.940 at 15° C. (59° F.). The oil should form a perfectly clear solution with twice its volume of a mixture of three volumes of alcohol and one volume of water, this solution being neutral or slightly acid to litmus paper. It is also readily soluble in carbon disulphide, or in glacial acetic acid. It consists chiefly of pulegone. The dose is 1–5 minims. The genuine or European pennyroyal is *Mentha pulegium* L. (*Pulegium vulgare* Mill.) in the same family. It has a similar taste and odor, and contains an almost identical volatile oil. HENRY H. RUSBY.

Hedonal, methyl-propyl-carbinol urethane, is ethyl carbamate with the ethyl radical replaced by the radical of methyl-propyl-carbinol. It occurs as a white crystalline powder with a salty taste; it is but slightly soluble in water, but is moderately soluble in dilute alcohol. Hedonal is a mild hypnotic, and may be considered fairly safe; it is efficient in cases of plain insomnia without mental excitement. The dose is 15 to 30 grains (1–2 gm.) or more, in cachets or in water; it has also been administered *per rectum.* As a rule it produces sleep in about half an hour. Recently it has been employed as an intravenous anesthetic. R. J. E. SCOTT.

Heidenhain, Rudolf Peter Heinrich.—One of the foremost physiologists of the nineteenth century. Born at Marienwerder, Prussia, January 29, 1834. He studied medicine at Königsberg, Halle, and Berlin, and received his doctor's degree from the university of the latter city in 1854. In 1859 he was appointed Professor of Physiology and Histology in the University of Breslau, and he continued to perform the duties of this office up to the time of his death, October 13, 1897. A few years before, he had been honored with the title of Geheimer Medizinalrat.

Among the most important of his contributions to the science of physiology are the following: "Physiologische Studien," Berlin, 1856; "Mechanische Leistung, Wärmeentwickelung und Stoffumsatz bei der Muskelthätigkeit," Leipzig, 1864; "Physiologie und Absonderungsvorgänge," in *Hermann's Handbuch der Physiologie*, Bd. V., Leipzig, 1880; "Die Vivisection im Dienste der Heilkunde," Leipzig, 1879; and "Studien des physiologischen Institutes zu Breslau," Leipzig, 1861–1868 (4 vols.). These studies, after 1868, were published in *Pflüger's Archiv* and in the *Archiv für mikroskopische Anatomie.*

A. H. B.

Heilbronn Mineral Springs.—Bradford County, Florida.

POST-OFFICE.—Starke. Hotels and boarding-houses in Starke.

ACCESS.—Viâ the main line of the Seaboard Air-Line Railroad, forty-five miles from Jacksonville. Starke, the county seat of Bradford County, is located on the elevated backbone of the Florida peninsula at an elevation of 180 feet above the ocean level. The location is surrounded on all sides by an almost unbroken pine forest stretching to the Atlantic on the east and the Gulf on the west, about fifty miles in either direction. The waters to the west flow into the Suwannee River and thence into the Gulf, while those to the east find their way into the St. John's River and ultimately reach the Atlantic. The situation thus unites many of the advantages of a well-favored natural sanatorium and offers an attractive resting place for the winter tourist in search of a genial and balmy climate. The mean temperature for the months of December, January, and February during a recent winter was 52° F. The rainfall for this period was 10.22 inches. Starke is well supplied with churches, a large school, livery stables, banks, hotels, boarding-houses, city lights, and waterworks. The springs are located about five and one-half miles northwest from Starke on a picturesque stream known as the Wateroak, from the presence of numerous trees which adorn its banks. They are reached by an excellent road. The springs are two in number, known as No. 1 and No. 2. No. 1 yields about one hundred and fifty gallons and No. 2, fifty gallons per minute. The following analyses were made by Prof. Henry Leffmann of Philadelphia:

ONE UNITED STATES GALLON CONTAINS

Solids.	Spring No. 1. Grains.	Spring No. 2 Grains.
Sodium chloride	2.08	1.42
Sodium carbonate	0.40	.60
Potassium carbonate	0.20	. .
Potassium sulphate	0.17	. .
Calcium carbonate	5.13	5.83
Magnesium carbonate	0.20	3.73
Ferrous carbonate	0.33	. . .
Silica	1.51	1.51
Nitrogen by permanganate	0.20	Trace.
Iron oxide and alumina		0.23
Total	10.22	13.32
Gases.		
Dissolved oxygen	0.92	0.67
Dissolved carbon dioxide	11.70	12.10

The water is free from organic impurities. It is tasteless, colorless, and odorless.

These are excellent waters of the light saline calcic type. No. 1 also possesses ferruginous properties. The water of No. 1 is very palatable and well adapted to table uses. Though not heavily mineralized these waters have acquired an extensive reputation among Florida physicians in the treatment of dyspepsia, chronic skin diseases, rheumatism, gout, diseases of the stomach, kidneys, bladder, and liver. Many practitioners recommend their local use as a lotion in ill-conditioned sores and indolent ulcerations. The waters are now used commercially and are bottled and shipped to distant points. EMMA E. WALKER.

Heister, Lorenz.—Born at Frankfort-on-the-Main, Germany, September 18, 1683. He began the study of medicine at the University of Giessen, in 1702. In 1706 he went to Amsterdam, where he had the good fortune to become the assistant of Ruysch, the anatomist; and in 1708 he obtained the degree of Doctor of Medicine at the University of Harderwick. In 1710 he accepted the Chair of Anatomy in the University of Altdorf, and ten years later he exchanged it for the same chair in the University of Helmstadt. Throughout the remainder of his long life Heister continued to serve this university in one capacity or another; occupying in turn the Chairs of Anatomy, Surgery, Botany, Pathology, and, finally, Practice of Medicine. His death occurred April 18, 1758.

The list of Heister's published writings is very long (not far from 200), and the topics treated cover the fields of anatomy, physiology, pathology, surgery, general therapeutics, gynecology, ophthalmology, gymnastic exercises, and botany. The following are among the more important of these publications: "Compendium anatomicum, etc.," Altdorf, 1717; "Chirurgie, in welcher, etc.," Nuremberg, 1724; "Compendium medicinæ practicæ, etc.," Amsterdam, 1745; "Kleine Chirurgie oder Wundarzney, etc.," Nuremberg, 1747; "Anatomisches-Chirurgisches Lexicon," Berlin, 1753. A. H. B.

Heliotherapy.—Heliotherapy, the term applied to the treatment of disease by means of the sun's rays, has, within the last ten years, through the work of Rollier of Leysin, Bernard of Samaden, Switzerland, and various German and French physicians, been brought prominently before the medical profession, and shown to be a valuable therapeutic measure in the treatment of surgical and other forms of tuberculosis.

The value and efficacy of sunlight has, in a general way, been recognized almost from time immemorial. Herodotus, Hippocrates, and Celsus speak of the beneficial effects of the sun's rays. The Romans had solaria attached to their houses, and the Temple of Epidaurus possessed a sun gallery.

It is a common experience that sunshine is conducive both to health of body and cheerfulness of spirits. "Where sunlight enters not there the physician goes," says the proverb.

Fig. 3116.—Children taking "Sun Cure" at Leysin

In the climatic treatment of disease the element of sunlight receives important consideration. Sanatoria are located with a southern exposure so as to catch as many of the sun's rays as possible. Hospitals now have their sun-parlors. The value of a climatic resort is largely judged by the amount of sunshine afforded.

Although in a general way sunlight has been utilized in the treatment of disease as subsidiary to other measures, it was not until quite recently that a systematic and scientific application of it was made in the treatment of surgical tuberculosis and various septic conditions, and it constituted the chief factor in the treatment. Bernard, in 1902, in the sunny Engadine valley of Switzerland found that sluggish wounds which would not heal under ordinary treatment rapidly healed under daily exposure of several hours to the intense sunlight of that altitude. Inspired by this experience he subjected other diseased conditions to the sunlight treatment, such as infected wounds, chronic ulcers, local tuberculosis and specific ulcers, and met with equally gratifying success.

In 1903 Rollier began his now famous clinic at Leysin, an Alpine village of 4,500 feet elevation above sea-level, for the heliotherapeutic treatment of surgical tuberculosis in adults and children, and his success has been such that his one sanatorium has now grown to three. To Rollier more than to any one else we owe the establishment of heliotherapy upon a firm clinical basis; he has demonstrated that a large number of cases of surgical tuberculosis, especially of the joints, could be cured without operation where previously resection was considered the only expedient.

Sunlight, as we know, is a composite, composed of light rays differing in length and effect; all, however, possess the property of heat, light, and chemical action. The violet or actinic rays are those which for the most part produce a chemical action. Beyond the visible spectrum are the so-called ultra-red rays on the one side and the ultra-violet rays on the other.

It is to the ultra-violet rays that the preponderant rôle in the effects of heliotherapy is generally ascribed. Dawnes and Blunt in 1877 first demonstrated that sunlight produced a bactericidal effect, retarding the growth of some bacteria and destroying others. Other experimenters have since corroborated this observation. Thus the tubercle bacillus is killed in from three to five hours according to the altitude, which means the intensity of the sun's rays; and the typhoid bacillus in an hour and a half by direct sunlight. Friedberger and Shioji[1] found that it was possiple to sterilize vaccine with the ultra-violet rays, and when

applied inside the mouth of a rabbit previously infected with various germs, the germs were rapidly killed. This antiseptic effect is supposed to be principally due to the chemical rays, though the other rays also probably play a part. It is upon this antiseptic action of sunlight that Rollier bases his results.

Although we do not yet fully know the effect of sunlight upon the body, experience, however, has shown that when the body is exposed to sunlight for a certain time, beside the local effect upon the diseased area, there is increased metabolism, increased elimination of toxins, improved nutrition, as shown in increased weight, greater cutaneous activity, increase in the hemoglobin, and in the number of red blood corpuscles. The nervous system is also stimulated. The local manifestation upon the body surface, outside of the diseased area, is the marked pigmentation or bronzing. Upon the pigmentation depends largely the prognosis, for it has been found that those cases which pigment intensely are generally the ones which recover most rapidly. Fair children pigment much less than dark ones and are more susceptible to tuberculosis than the latter. Furthermore, the increased activity of the pigment cells appears markedly to increase the power of resistance to disease. This was illustrated by an outbreak of chickenpox among Rollier's children. All who were deeply pigmented escaped the infection, while those wearing bandages or an apparatus had the eruption on those portions of the body from which the sun's rays had been excluded by the bandage, while on the pigmented portion the eruption was absent.

Other things being equal, it is evident that the most favorable results from heliotherapy are obtained where the sun's rays are most intense and there is the least absorption from the atmosphere, and these conditions are best fulfilled in the altitudes. Experiment has shown that twenty-five or thirty per cent. of the sun's rays are absorbed by the atmospheric dust and moisture before they reach the level of the sea; whereas on the top of Mt. Blanc (15,800 feet) only six per cent. of the efficiency of the sun's rays are lost. We have, then in the altitudes, purity and great diathermancy of the atmosphere, absence of dust, low humidity, and the radiation of light from the snow in winter, in the more northern latitudes, as at Leysin. On the other hand, there are occasional storms and fogs and sometimes violent winds. For example: in a visit made by the writer to Leysin in May the whole village was enshrouded in fog. To obtain the best results from altitude, says Jaubert,[2] the elevation should be from 2,000 to 3,600 feet; there should be a southern exposure, and shelter from the prevailing winds, as upon the side of a hill or mountain.

Although it is true that the most intense insolation occurs at the altitudes, experience has demonstrated that heliotherapy can be applied with excellent results at certain seashore stations, such as some on the Adriatic or Mediterranean coast, or those offering similar conditions in this country. A favorable seashore station for the application of heliotherapy, says Jaubert, should be one affording cleanness of the air, reflection from the surface of the sea, a sea breeze producing a constant change of air, and shelter from land breezes and winds. It is also to be borne in mind that in the treatment of surgical tuberculosis in children there is the added advantage of the sea air and sea bathing at seashore stations, which is of very definite value as the experience of many years has demonstrated.

Moreover, heliotherapy can be applied in hospitals situated in cities, as Bardenham of Cologne has shown, and Reverdin of Geneva, who transferred his patients directly from the operating room to the hospital garden.

Fig. 3117.—Children Skiing at Leysin

It is further to be remembered that in the application of heliotherapy either at the altitudes or seashore, pure air, rest, proper and sufficient food, and good hygienic conditions also play their part.

Thus far the principal applications of heliotherapy and its triumphs have been in cases of surgical tuberculosis in adults and children, particularly in the latter. Here is where Rollier has achieved his remarkable success. Pott's disease, coxalgia, osteitis, polyarthritis, many cases with abscesses, sinuses, fistulæ, and secondary infections; open tuberculosis of the hand, foot, elbow, and shoulder, are especially suitable to this treatment and show excellent results. One striking feature is the almost immediate relief from pain. Necrosed bone is spontaneously eliminated, and in many cases, spontaneous movement occurs after repair. Tuberculous peritonitis, renal, pelvic, and thoracic tuberculosis, that of the eye and ear and adenitis likewise show good results. Perhaps the greatest field of usefulness of heliotherapy is in septic cases, where the bactericidal influence of the sunlight exercises its potent power.

Rollier in ten years has treated 1,129 cases—652 adults and 477 children; of these 30 cases have ended fatally, 41 remained stationary, 112 improved and 945 were cured. Of the whole number 804 were closed tuberculosis on arrival at Leysin, of which 703 were cured, or eighty-seven per cent., 325 were open cases of which 242 were cured, or seventy-four per cent.

Dr. L. Revillet of Cannes[3] reports excellent results in the heliotherapeutic treatment of children suffering from surgical tuberculosis at Cannes upon the Mediterranean Littoral. A number of Swiss children with closed local tuberculosis were sent to this station, being examined both before departing and on returning by Prof. d'Espine, thus verifying the results. The treatment lasted from the middle of October to the middle of June. The diseased region was exposed to the sun at first for one-half to one hour, and when toleration had been established from two to three hours, and finally for a greater part of the day, the head and eyes being protected. In addition, the children were given sea baths daily, lasting from one to three minutes. It was found that sun baths were possible for 190 out of 240 days. The effect was striking: appetite, color, and spirits returned and the average gain in weight was 4 kilograms. Of 63 children suffering from Pott's disease 27 were cured, 26 improved, 6 remained stationary and 4 died. Of 94 suffering from hip disease and white swelling, 33 were cured, and 50 improved. In tubercular peritonitis the effusion and meteorism rapidly disappeared, and in 7 cases 3 patients were cured, 3 improved and 1 died. In 11 cases of lupus 8 were cured and 3 improved. Old glandular sinuses rapidly closed.

d'Oesmitz of Nice[4] reports three cases of tuberculous peritonitis with ascites cured by heliotherapy in one, three, and five months, all signs of peritoneal lesion completely disappearing. At first the abdomen was exposed to the sun for five minutes, lightly covered with some thin material, and the exposure increased daily for five minutes until a maximum of two hours was obtained. If the action of the sunlight appears to be too energetic the duration of the exposure can be shortened or temporarily suspended.

Poncet and Leriche[5] advise, in cases of ascitic tuberculous peritonitis the union of laparotomy and sunlight exposure, and consider the results much more rapid than the sun cure alone and much more lasting than laparotomy alone.

Tuberculous laryngitis has also been treated by heliotherapy, the sunlight being reflected into the larynx by means of a reflector and the laryngoscopic mirror, and the results are said to be encouraging.

Rollier's method of applying heliotherapy is as follows: After a short period of rest in bed and exposure to the mountain air from open windows, the patient's bed is wheeled out into the open gallery which communicated with the ward and faces the south. He is thus accustomed to the open air and the altitude. He is then gradually exposed to the sun, beginning with the lower extremities and so on gradually until at the expiration of a week or ten days the entire body is exposed. The exposures are short to begin with, and then gradually lengthened until a daily insolation of from four to six hours is attained. The head is protected for some time while the complete insolation is being reached. When toleration is once established the treatment is borne without discomfort both in summer and winter.

Some authorities, and Rollier also, sometimes expose only the diseased part, beginning with an exposure of one-half to one hour, and gradually increasing until it is continued the greater part of the day. Poncet and Leriche, before quoted, advise at first an exposure of the whole body for ten minutes, and if this is not possible, the diseased part alone is exposed at first for ten or fifteen minutes for four or five days, and this is gradually increased until a period of three hours forenoon and afternoon is reached.

No rigid plan of heliotherapy can be applied to all patients, but, as in all treatment, each must be individualized, the dose of sunlight depending upon the local reaction which, in turn, depends upon the activity of the tuberculous process; and upon the general effect. If the treatment is too severe from too long an exposure or too sudden, it is indicated both by increased local congestion and inflammation, and by increase of temperature and pulse, insomnia, loss of appetite, and general malaise. If, in patients with sensitive skin, erythema or eczema is produced the part can be protected with a fine gauze silk covering of a deep red color. As the treatment progresses, the skin becomes bronzed and finally deepens from a coffee to a chocolate color. Upon the pigmentation of the skin, as has been said above, the prognosis of the case largely depends, which is favorable in proportion to the rate and completeness of the bronzing. As a result of the pigmentation the patients do not feel the cold even when uncovered or on sunless days.

In tuberculosis of the joints Rollier immobilizes the parts but with removable appliances which can be removed during the exposure period. Surgical interference is only employed symptomatically, such as the aspiration of a cold abscess when not absorbed, or a suppurating lymph node. The duration of the treatment depends, of course, upon the case and its response, extending from months to one or two years.

What cases do best at the altitudes and what at the seashore under heliotherapy it is difficult to say. Local tuberculosis associated with a secondary pulmonary tuberculosis in evolution, however slight may be the lung affection, is considered to be more favorably influenced at the altitudes; while adenopathies, superficial tuberculosis, scrofula, rachitis, osteoarticular deformities of youth and adolescence, and all inflammatory tuberculoses do well or better at the seashore.

In a personal visit to the Children's Ward of Rollier's Sanatorium in 1912 the writer was impressed with the remarkable appearance of the little patients; their general condition seemed excellent, they were happy and laughing, and the local disease in the majority of cases seemed well on the way toward cure. They were so bronzed from the sun that it was difficult to say to which race they belonged.

Heliotherapy may not be all that Rollier and others in their enthusiasm claim for it, but it has at least vindicated its value as a valuable therapeutic measure in the treatment of surgical tuberculosis and incidentally has demonstrated that the conservative treatment of this class of cases produces such satisfactory results that radical surgical interference should be resorted to only after a careful trial of Rollier's plan of treatment by heliotherapy, which can be applied

more or less completely whenever there is a fair amount of sunshine.

In this country there are many regions where heliotherapy can be admirably applied -regions possessing both altitude and an abundance of sunshine. Such conditions are afforded, for example, in Colorado, New Mexico, Arizona, southern California, and in the Pine Belt of the South. There are also excellent seashore resorts that could be utilized for this purpose both in the North and South.

EDWARD O. OTIS.

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Heliozoa.—An order of non-parasitic protozoans. The sun-animalicule, *Actinosphærium*, is an example. See *Protozoa*. A. S. P.

Hellebore, American.—See *Veratrum Viride*.

Hellebore, Black.—HELLEBORUS NIGER. *Christmas Rose.* The dried rhizome of *Helleborus niger* L. (fam. *Ranunculaceæ*). This is a low perennial herb of Southern Europe, mostly in the mountains, and largely cultivated for its winter bloom.

The drug much resembles cimicifuga or black cohosh, but is rather smaller, blacker, and more tortuous, with fewer and broader wood-wedges in the rhizomes, and those of the roots less conspicuously stellate. It contains the two poisonous glucosides helleborin and helleborein, and has been used as a drastic. In overdoses it is an emetico-cathartic poison. It is now little used. The dose is gr. viij.–xx. (0.5–1.5).

The rhizome of *H. viridis* L. or green hellebore (but not to be confused with *Veratrum viride*, also so called), is very similar, and even more highly acrid and poisonous. HENRY H. RUSBY.

Hellebore, Green.—See *Veratrum*.

Hellebore, White.—See *Veratrum*.

von Helmholtz, Hermann Ludwig Ferdinand.—Born in Potsdam, near Berlin, Germany, August 31, 1821. He studied medicine in Berlin and received his doctor's degree in 1842. After holding various positions of minor importance in Berlin and Potsdam, he was called in 1849 to occupy the Chair of Physiology and General Pathology in the University of Königsberg. Six years later (1855) he was transferred to the Chair of Anatomy and Physiology in the University of Bonn. In 1858 he went to Heidelberg, as Professor of Physiology, and remained there until 1871, when he was called to Berlin to occupy the newly established Chair of Physics, and at the same time to be the Director of the Institute of Physics, with the title and emoluments of a "Geheimer Regierungsrat." In 1883 he was given a patent of nobility, and in 1888 he was elected President of the Royal Physico-Technical Institute at Charlottenburg—an office which virtually placed Helmholtz, who had then reached the age of sixty-seven, in honorable retirement. In 1891, on the occasion of his seventieth birthday, the well-merited title of "Excellency" was conferred upon him. He died September 8, 1894, from an attack of cerebral apoplexy.

Helmholtz laid the foundations of his great reputation as a physiologist when he published his celebrated treatise on the conservation of energy ("Ueber die Erhaltung der Kraft, Berlin, 1847). Then, for a few years, he devoted himself energetically to the physiology of the special senses, and as a result of his labors he invented the ophthalmoscope, an instrument which not only revolutionized ophthalmology, but at the same time proved of inestimable value to human pathology and therapeutics. The announcement of this discovery was made in the monograph which he published independently under the title: "Beschreibung eines Augenspiegels zur Untersuchung der Netzhaut im lebenden Auge," Berlin, 1851. During the following decade Helmholtz published two large treatises, which mark a veritable epoch in the history of medicine, viz.: "Handbuch der physiologischen Optik," Leipzig, 1856–1866; and "Die Lehre von den Tonempfindungen," Braunschweig, 1862 (2nd edition, 1865). A large number of his minor contributions to medical literature will be found scattered throughout the following periodical publications: *Mueller's Archiv, Poggendorff's Annalen, Crelle's Journal für Mathematik, von Graefe's Archiv, Virchow's Archiv,* and *Archiv für Anatomie und Physiologie.* (Pagel.) A. H. B.

Helmitol is a combination of hexamethylenetetramine with anhydromethylene citric acid, $C_7H_6O_7.(CH_2)_6N_4$. It occurs in colorless crystals, soluble in ten parts of water, almost insoluble in alcohol and ether. It is slowly decomposed in dilute acid solutions, readily in alkaline solutions with the liberation of formaldehyde. Solutions have an acid taste and reaction.

Helmitol is a urinary antiseptic in much the same manner as is hexamethylenamine. It is equally efficient in acid or alkaline urine. Used in chronic urethritis, cystitis, and chronic affections of the bladder, it arrests the alkaline fermentation of the urine, relieves tenesmus, and is said to be especially useful in pyelitis and as a urinary disinfectant following typhoid fever. Dose: 10–15 grains (0.6–1.0). R. J. E. SCOTT.

Heloderma.—A genus of lizards which contains two species. *H. suspectum* the "Gila monster," is poisonous. It is found in the south western United States. *H. horridum*, a Mexican species is probably venomous also. A. S. P.

Helouan.—See *Egypt*.

Helvetius, Adrian.—Born in Holland about 1661. As soon as he had completed his preliminary studies he visited Leyden for the purpose of fitting himself for the career of medicine. On attaining the age of twenty he went to Paris, not with any fixed intention, however, of establishing himself there permanently as a practitioner of medicine. But from the very beginning he met with such success in the treatment of the few patients who came under his care, that Colbert, the celebrated Intendant of Louis XIV., took him under his special protection. The dauphin, the son of the king, was suffering at this time from an attack of dysentery, and Daquin, the Court Physician (probably at Colbert's suggestion), asked Helvetius to see the patient with him in consultation. The remedy which he recommended, and the nature of which he was then unwilling to divulge, effected a complete cure. Père Lachaise, the King's confessor, induced his royal master to purchase from Helvetius, for one thousand louis d'or, the revelation of this remedy which had proved so effective a cure of dysentery. It was then learned that the remedial agent was simply ipecacuanha, a drug already well known for its beneficial action upon the disease in question. Helvetius was knighted, was made Inspector General of the hospitals of French Flanders, and was appointed the physician-in-ordinary of the Duke of Orleans, then Regent of the Kingdom. He died in Paris, February 20, 1727. A. H. B.

Hematemesis.—The loss of blood is always worthy of consideration, as is the loss of any highly specialized product of the bodily economy, requiring complicated metabolic processes for its replacement.

When the origin of a hemorrhage is known, or the lesion can be definitely located, the situation is simplified; the enemy is "in the open," and can be combated by fair means. When, however, the blood wells up from some hidden source, or escapes from some inaccessible viscus, the possible gravity of the occurrence looms up in the mind of the physician, and differential data at once assume the highest importance. It is, therefore, my purpose to bring out and make plain the stronger inferences to be fairly drawn when hematemesis suddenly appears, for oft times a positive opinion is out of the question, as those will admit who have followed their patients to the operating room, or, worse still, to the autopsy.

In the first place we must decide if the vomitus really contains blood, or is colored by food previously ingested, such as red wine, cherries, cranberries, or any red vegetables or fruits; also there may be pseudohematemesis, where certain preparations of iron or bismuth have been taken. To demonstrate by microscopic or chemical means that a supposed hemorrhage is only a harmless coloring matter affords decided relief to both physician and patient.

Next to be considered is whether the hemorrhage is from the stomach, or extragastric in origin. A previous hemoptysis or epistaxis should be considered, remembering that in hematemesis proper the blood is generally dark red or almost black, that it contains no air bubbles, that it is often acid in reaction from the presence of the gastric juice, that it is vomited without coughing, that it frequently contains food particles, that objective lung symptoms are absent, while objective stomach symptoms are usually present.

An epistaxis occurring previously during sleep, where the blood has been unconsciously swallowed, may not be so easy to differentiate, and for that reason the nasal cavities should be closely inspected for erosions or polypi.

Other rare extragastric causes are hemorrhagic infarctions of the lungs, an aneurysm gradually leaking into the stomach, or abscesses or fistulæ in the vicinity of that organ, which may perforate it.

Having decided that the flow of blood originates in the stomach or esophagus, we then desire to locate the pathological change bringing about this manifestation, and the first thought is of gastric ulcer. This is a fair assumption if the patient is under middle age, and gives a history of past attacks of acid dyspepsia or painful indigestion, this history perhaps running over a number of years.

In this connection it is proper to state that, while the presence of hematemesis is strongly indicative of ulcer, its absence means little, for many extensive ulcers, giving rise to pronounced constitutional symptoms, lack this phenomenon in their course.

I may state, therefore, that a fulminating gastric hemorrhage in an individual of comparative youth, accompanied by no cachexia, and preceded by a characteristic history, justifies the diagnosis of a ruptured artery in the "floor" of an ulcer.

On the other hand, when the patient is beyond middle life, when cachexia is noticeable, with a record of gradual decline in health, perhaps preceded by an ulcer history; where there is no free hydrochloric acid in the vomitus, but perhaps lactic acid, where evidences of pyloric obstruction can be demonstrated, even though there be no objective manifestations, the medical attendant may be fairly sure of malignant trouble, with a correspondingly gloomy outlook for the sufferer.

Duodenal ulcer is, in my opinion, a more frequent cause of hematemesis than has been realized, and only within the past few years has the profession become fully alive to the prevalence of this lesion. Where the patient is a man, where a history of black, tarry stools is elicited, coincident with pain two to four hours after meals, rather to the right side, and where there is abundant free hydrochloric acid in the stomach contents, we may reasonably infer the presence of a duodenal ulcer, whose hemorrhage has partly overflowed into the stomach, thereby setting up the hematemesis.

In women, during the sexual life, where there is little complaint of indigestion, but the menses are irregular, vicarious menstruation must be held in mind. Two years ago there came under my observation a striking instance of this sort. A young married woman, flat-chested and anemic, about every third month would have a copious hemorrhage from the stomach. Her menstruation, at all times scanty, did not appear during the month of hemorrhage, and she stated that, apart from the nervousness provoked by the sight of vomited blood, she really felt better for several weeks afterward.

If the physician can confidently diagnose vicarious hemorrhage from the stomach, it will naturally make the greatest difference both in treatment and prognosis.

Cirrhosis of the liver should come to mind when during or past middle life the patient, with little previous history of indigestion, but who has been a "high liver," or possibly a hard drinker, vomits a large amount of blood with little or no pain.

In March, 1909, I was hastily summoned to attend a man forty-four years of age, who had been on an alcoholic debauch for a week, and who, while in the toilet evacuating his bowels, began to vomit large quantities of blood, so large that he fainted. When I saw him, the tiled floor and tinted walls of the toilet were bedaubed with blood, while he, collapsed, was limply wallowing in his own gore. The prompt administration of adrenalin and calcium chloride controlled the hemorrhage, and more leisurely examination demonstrated a cirrhotic liver.

It has been shown by several investigators that the source of hematemesis in cirrhosis of the liver is frequently a ruptured vein in the lower end of the esophagus, which has been overdistended. Should the vein be quite small, there may be no hematemesis, but tarry stools instead. Usually, however, the hemorrhage is profuse, and occasionally, as expressed by

Dr. W. F. Cheney, "may constitute the last instead of the first scene in the drama."

Ruptured esophageal varices from other causes may excite hematemesis, but, apart from portal obstruction, such is most rare, and may be justly regarded as an early indication of hepatic cirrhosis, even where no other symptoms can be demonstrated.

Another cause of appreciable frequency is the presence of abrasions of the gastric surface (two to four millimeters in diameter), multiple in character, and extending partly through the mucosa. Erosions may also arise from swollen lymphoid follicles in the gastric mucosa, which suffer degenerative changes leading to rupture. Then there are sometimes simple hemorrhagic erosions found in patients greatly run down, in advanced tuberculosis, and in confirmed alcoholism.

Among local causes to be considered are the racking strain of continuous vomiting, overdistention of the stomach by CO_2, or the inexpert insertion of a stomach tube, whose openings are not properly rounded off. In this connection I might mention that I have seen some stomach tubes of stiff rubber, with openings at the end surrounded by edges of knife-like sharpness. The introduction of such a tube by a tyro possessing more zeal than knowledge is exceedingly risky, subjecting the patient to grave dangers of both present and future gastric hemorrhage.

Splenic anemia, according to Dr. T. R. Brown, is not so rare a cause, and where there is splenic enlargement with diminished leucocytes, and not much history of distinctive gastrointestinal disturbances, this condition may be suspected, though hard to diagnose positively.

Among other causes are several dyscrasias, as pernicious anemia, the leukemias, and purpura hemorrhagica, though in the last-named the hematemesis may be only one manifestation of many bleeding surfaces.

Finally, the hemorrhage may arise from toxic gastritis subsequent to the swallowing of corrosive poisons, or from trauma, in which events the history is generally all-sufficient to name the cause.

Prognosis.—Paradoxically as it may appear, this depends much more on the cause behind the hemorrhage than the severity of the bleeding itself. In serious constitutional diseases hematemesis often marks the beginning of the end, and may even constitute a terminal symptom. In cirrhosis of the liver a single hemorrhage early in the course of the process frequently seems to exert a beneficial effect, being followed by a diminution in the size of that organ.

By way of parenthesis I might remark that sometimes a brisk hematemesis may so frighten a patient who has been guilty of various forms of intemperance, that a moral regeneration ensues, followed by a decided improvement of the chronic trouble.

When it can be demonstrated that the blood flows into the stomach from outside structures, as a leaky aneurysm or fistulous tract, the prognosis is serious. Often this demonstration cannot be made. Should the hemorrhage be putrid, deep ulcerations may be suspected, with grave danger of death from perforation or sepsis.

In the case of profuse hematemesis it is almost impossible to differentiate between the rupture of a large or small vessel, nor can we with certainty say what vessel is affected, nor prognosticate a recurrence. Some of the most copious hemorrhages have no visible anatomical lesions of the mucosa, and Lebert, a German investigator of wide experience, asserts that not over three or four per cent. of large hemorrhages from the stomach are fatal.

In hemorrhage from simple ulceration the prognosis depends largely on whether the patient will submit to intelligent and persistent treatment, for continued hyperacidity, as well as improper diet, may keep up the ulceration, and bring about renewed bleeding. In any event, for ten days after any decided hematemesis all prognoses should be most carefully advanced. After that time the imminent danger diminishes, though a recurrence must be borne in mind, especially when existing pathological excitants have not been removed.

The most comforting feature of prognostic import is the fact that the first hemorrhage is rarely fatal, so that, after emergency therapeutics have been instituted and the bleeding checked, the physician generally has both time and opportunity to institute more leisurely and thorough measures leading to the abatement of present lesions, as well as the prevention of future onsets.

Treatment.—Single large hemorrhages are best treated medically. Surgery is either not necessary, or the patient is so exsanguinated as to render an operation of such magnitude unwarranted. Abstinence from all food or drink should be absolute for the time being. Ice-bags may be applied to the epigastrium to promote firm contractions of the stomach. To combat syncope or other symptoms of acute anemia, the head may be lowered, the foot of the bed elevated, and liquids may be administered subcutaneously or by the rectum.

Unless specially contraindicated, a hypodermic of morphine may be given to promote physical and psychic quietude, both of which are necessary to promote the formation of a clot at the bleeding point. The patient should also be encouraged so far as is consistent with the truth, for a placid mind exercises a salutary influence over the lower centers at all times.

In hematemesis adrenalin is the one drug *par excellence*. The solution of adrenalin chloride (1 to 1,000) may be given in ten-minim doses every hour. The reaction dilatation of the blood-vessels that follows its use need not be considered in acute hemorrhage.

Gelatin has proved disappointing, though a three per cent. solution by the rectum can do no harm, and may accomplish some good by introducing liquids into the system. It should not be given by the mouth, as nothing should be allowed to enter the stomach during the time of active bleeding.

The advice given by a few clinicians that gentle lavage with ice water be used and continued until the return flow is nearly clear is not correct in my opinion. No matter how expert or careful may be the operator, the end of the tube is liable to impinge upon the eroded area of the gastric mucosa to its possible detriment.

After the hemorrhage has ceased for two or more days a modified Lenhartz diet may be inaugurated and increased rather rapidly.

Chronic hemorrhages may be treated by gelatin by mouth in doses of a three per cent. solution every one or two hours, or by calcium chloride in twenty-grain doses by rectum every four hours. Adrenalin should not be employed for any length of time, as its prolonged use causes vasomotor dilatation.

The subcutaneous injection of blood serum has at times seemed highly beneficial. Human serum whose suitability has been previously tested, as for transfusion, is best, although in emergencies untested serum may be employed, as the risk involved from hemolysis and agglutination is probably slight. Next best are rabbit and horse serum. The danger from anaphylaxis, though improbable, must be borne in mind.

From 10 to 15 c.c. of serum may be injected at one time, and the injection repeated on successive days, if necessary, or even at shorter intervals. The blood should be obtained under the strictest aseptic precautions from a superficial vein, and in sterile flasks should be kept on ice until the serum has sufficiently separated. The effect of the serum treatment probably begins about six or eight hours after the injection, and lasts for several days. In urgent cases of

hemorrhage direct transfusion of blood is occasionally indicated.

Should all of these measures fail, and the continuance of repeated hemorrhages cloud the prognosis, surgical interference may be advisable, though this should be undertaken only after very careful consideration. GEORGE M. NILES.

Hematidrosis is a functional disturbance of the sweat apparatus whereby blood, through diapedesis into the coils and ducts from their surrounding vascular plexus, becomes mingled with the sweat and appears with it upon the normal skin, producing the phenomenon of so-called "*bloody sweat.*" It is an exceedingly rare occurrence, and when observed the subject has been generally a highly neurotic person undergoing some strong emotional disturbance. In some instances it has seemed to be a form of vicarious menstruation. Darier states that most of the cases reported are open to the suspicion of faulty observation. He has never seen a case and knows of none which are unquestionable. It has been observed in the new-born. The points where it has been observed to occur are the face, ears, umbilicus, feet, and hands in limited areas, giving rise to the term "bleeding stigmata" and other names. According to Ch. Audry the most frequent sites of the affection are the ends of the fingers. This writer also claims that the bleeding area is always limited and more or less circular. He compares the condition to that seen in premenstrual bleeding from the mucous membranes—particularly those of the nose. Treatment is that of the patient's general condition, with particular reference to hysteria and hemophilia.

CHARLES TOWNSHEND DADE.

Hematin is the iron-containing portion of hemoglobin. By combining with a protein, globin, this iron-rich compound forms the compound protein which gives the characteristic color to blood. It is the iron-containing portion that is responsible for the red color. F. P. U.

Hematocele.—This term, meaning literally a blood tumor, is commonly used in reference to an accumulation of blood in some of the canals or natural cavities of the body, in contradistinction to hematoma, which is used to designate an accumulation of blood in the tissues where it dissects out a cavity for its own accommodation. Under the term hematocele are usually described bleedings into the tunica vaginalis testis, into the pelvis whether intra- or extraperitoneal, and into the labium majus.

In general a blood cyst is the result of direct injury, causing the rupture of vessels without loss of continuity of the overlying structure, or is due to the spontaneous rupture of vessels where the blood is unable to escape from the body and accumulates in a mass.

These accidents may occur in any location and unless the vessel is large, the bleeding is soon checked by the gradually increasing pressure upon the bleeding vessel by the accumulating blood.

If the vessel is large, the bleeding may go on indefinitely and cause enormous swelling and finally pressure necrosis of the surrounding structures with resulting external hemorrhage. If the bleeding is free into a large closed cavity, as the peritoneum, a fatal result will often follow. These blood tumors, if accessible to the hand, may be felt as boggy masses with semi-fluid contents. The onset is usually sudden and is accompanied by sharp pain and rapid swelling at the point of hemorrhage. There is often considerable inflammatory reaction in the tissues about the mass, which subsides in a few days if the pressure is not too great. The blood may be absorbed after a variable time. Usually the fluid portions first and finally the solid portions gradually disappear or they may become organized and form scar tissue. At times suppuration occurs in the blood clot.

TREATMENT.—Many times the collection of blood is small and requires no treatment. A pressure bandage will often aid in controlling the hidden bleeding or an ice cap may be used. Healing is often accelerated by incising the swelling, turning out the clot and securing the bleeding vessel. The wound can then be closed by sutures or packed with gauze. This must always be done if the injured vessel is a large one and the tissues are in danger of necrosis or if the bleeding is free into a large cavity. When suppuration occurs, the treatment is that of abscess.

HEMATOCELE OF THE TUNICA VAGINALIS may be acute or chronic. In the first instance, it may result from injury to the testicle, such as rupture, puncture, a violent blow, or severe muscular strain. Severe coughing has been known to produce it. When the flow of blood is profuse, the tunica vaginalis may rupture and give rise to hematoma in the scrotum outside of the tunic. In this case a purple swelling forms, about the shape of the testicle itself. At times the effusion into the tunic is complicated by a scrotal hematoma without rupture of the tunic.

Hematocele caused by injury usually takes place into a previously normal tunica vaginalis. It is sometimes caused by tapping a hydrocele, in which case a diseased tunic is present at the start. Spontaneous hemorrhage usually occurs in the previously inflamed walls of a hydrocele.

If the blood is confined to the tunica vaginalis, discoloration of the scrotum does not occur and the swelling is pyriform, having its largest diameter at the most dependent portion. The blood may clot or remain fluid, giving rise to a smooth, tense fluctuating swelling much resembling a hydrocele. The tumor is not penetrated by light, thus differing from hydrocele, and is much more sudden in its onset. When the hemorrhage is severe enough to cause rupture of the tunic or there is complicating hematoma, the characteristic outline of the distended tunica vaginalis is obscured and can be made out only when the outlying blood has been absorbed.

Symptoms.—This form comes on with acute pain, often of the sickening character always produced by pressure upon the testicle. The swelling develops rapidly and has already been described. Complete absorption may occur, but as a rule the changes of chronic hydrocele take place in the walls of the tunica vaginalis.

The chronic form takes place in the course of chronic inflammation of the tunica vaginalis and has been called periorchitis hemorrhagica. The bleeding is caused by the rupture of vessels in the vascular membrane lining the tunica vaginalis which results from the inflammation.

Gosselin describes three degrees, based upon the extent of the disease in the walls of the vaginal tunic. First, a vascular membrane lining the tunica vaginalis, easily separated from it, and walls which collapse on removing the contents of the sac. Second, a much thicker vascular membrane and thickening of the tunic itself so that the walls are more or less rigid and collapse is not possible after evacuation of the contents. The third degree includes walls which are very rigid with areas of calcification and cartilage formation and, in a case reported by Bardigan, ossification of the tunica vaginalis. Other portions show areas of hemorrhage into the tissues and soft granulations and the false membrane lining the sac is firmly adherent. At times its blood supply has been cut off by fibrous tissue changes and sloughs have resulted.

The contents of a chronic hematocele consist of blood in a more or less altered state, sometimes mixed with hydrocele fluid. It may be fluid, red and clear,

containing clots in the latter case, or dark even almost black and varying from a syrupy to a gelatinous consistency when blood alone fills the sac.

The testicle can often be located in recent cases, by eliciting the sickening sensation by pressure upon it. In older cases, the inflammatory changes have often involved the organ until it is partially or completely destroyed. Malignant change sometimes occurs in the testis, but probably the hematocele in these cases was secondary to the cancerous growth.

Diagnosis.—Chronic hematocele like chronic hydrocele is a disease of late life, usually occurring between the fortieth and sixtieth years. Its development is slow and characterized by exacerbations, when additional hemorrhage occurs, and the sac becomes more distended and inflamed at these times. Otherwise the swelling is painless, tense and elastic, or hard and resistant, dependent upon the state of its walls and contents. At times it is nodular because of calcification in the walls of the sac. Light will not penetrate the swelling. The final diagnosis rests upon the result of aspiration of the sac when some blood or modified bloody fluid is obtained.

The disease must be differentiated from hydrocele, hernia, especially omental hernia, and solid swellings of the testicle.

In hydrocele the shape of the swelling is the same, but it is translucent, and the fluid obtained by tapping is clear.

In hernia there is a history of reducibility or it is reducible. An impulse is felt on coughing and the swelling can be traced up into the inguinal canal. It may be impossible to differentiate the more firm varieties of hematocele from a chronic orchitis or tumor of the testicle, except by puncture or incision. In some instances the hematocele is dependent upon the development of one of these conditions primarily. There is no spontaneous cure of these cases, they continue to enlarge, often until their bulk renders them very inconvenient and the pain during exacerbation of the hemorrhage is considerable.

If allowed to progress the testicular function is ultimately destroyed and suppuration is a not infrequent accident, especially after tapping.

Other forms of hematocele in this region are occasional blood tumors in the testis or in the cord. In either situation we may have a diffuse or an encysted form.

The diffuse hematocele of the testicle is due to injury of the organ. The pain is severe and persistent and in the absence of hydrocele, hemorrhage into the parenchyma may be suspected, but can be proved only by puncture.

Encysted hematocele of the testis is indicated by sudden enlargement and inflammatory change in an encysted hydrocele of the testis; the swelling fluctuates early but is not translucent.

In the cord the diffuse hematocele is sausage-shaped, due to hemorrhage into the sheath of the cord, and the chronic cases may be of very large size. In the encysted form hemorrhage takes place into an encysted hydrocele of the cord, or the effused blood becomes encysted in the cord. The tumor is pear-shaped and may become merged with the epididymis and testis.

Treatment of hematocele in the tunica vaginalis or surroundings should consist in limiting the hemorrhage as far as possible, preventing or reducing inflammation, and finally getting rid of the products of hemorrhage with as little added damage to the parts as possible.

In acute cases due to injury, the patient should be put to bed and the ice cap applied. If the bleeding persists an incision should be made, clot removed and the bleeding point secured. The wound is then closed without drainage. Hemorrhage outside the tunica vaginalis in the scrotal tissues will usually take care of itself. In the testicle itself, exploration should be made with a fine needle and the hemorrhage, having been found, should be treated as above. A diffuse hemorrhage in the cord can often be controlled by a firm pressure bandage.

In the chronic form, whether in the tunica vaginalis or cord, the sac may be incised and as much of the wall cut away as can be, the cavity lightly packed and allowed to heal by granulation. If the walls are rigid and will not collapse, they must be dissected away and the cavity packed. If the testis itself is destroyed, castration is the operation of choice, especially in old patients.

Pelvic Hematocele.—This is due to the extravasation of blood into the pelvis either within the peritoneal cavity or extraperitoneal. In the last instance it is sometimes called pelvic hematoma. In the vast majority of cases this bleeding is the result of extrauterine pregnancy, but other cases have been reported where this cause could be excluded. These cases have resulted from perforation of the uterus, rupture of an ovarian cyst, rupture of an ovarian follicle, rupture of a varicose vein in the broad ligament or the tearing of pelvic adhesions. Secondary hemorrhage after operation or rupture of the pregnant uterus are also causes.

Jayle has reported cases of rupture of a vessel in the ovary causing ovarian hematoma with secondary rupture which gave rise to pelvic hematocele. A large vessel on the surface of a fibroid may rupture with profuse hemorrhage. All these causes are most likely to be effective during the menstrual congestion, except, of course, those connected with labor or operative procedure.

Extrauterine pregnancy acts as a cause, either by what is known as tubal abortion or actual rupture of the tube, enclosing the gestation sac.

In tubal abortion or intratubal rupture, as it is called, the gestation sac ruptures, giving rise to hemorrhage into the tube which may gradually force the ovum out through the abdominal ostium in which case the bleeding soon ceases. If the ovum remains partially attached the blood will continue to flow out into the peritoneal cavity giving rise to hematocele, or if the abdominal ostium is occluded it will give rise to hematosalpinx.

When rupture of the tube takes place it usually occurs at the placental site because of weakening of the walls by the invasion of the chorionic villi and it is usually spontaneous, though at times it results from violence, as a vaginal examination, coitus, a fall, or over-exertion. The rupture may occur in such a location as to cause the blood to escape under the peritoneum, in which case it is under pressure from the stretching of the elastic peritoneum, and the amount of blood lost is limited, unless secondary rupture occurs into the peritoneal cavity. If rupture occurs directly into the peritoneal cavity or even secondarily, it is likely to prove rapidly fatal, unless limited by preexisting adhesions or controlled by operation. The ovum may escape through the tear or, if the rent is small, be retained in the tube and only the blood escape through the opening.

In severe intraperitoneal hemorrhage from any of the above causes, the blood fills the pouch of Douglas, then surrounds the uterus and mounts on into the false pelvis and lower abdomen. If an immediately fatal termination does not result, the blood in time clots, the more fluid portions may be absorbed, adhesions form over the mass and it becomes encapsulated.

If the bleeding is only a slow leakage or only a limited amount escapes, it may become encapsulated in one or the other side of the Douglas cul de sac. Sometimes the blood is confined from the start by previous peritoneal adhesions forming a roof over it and thus preventing the rapidly fatal form of hemorrhage.

The capsule formed over these blood accumulations

consists of fibrin and plastic lymph which bind the intestinal coils to the uterus, tubes, and pelvic walls. When the bleeding takes place between the folds of the broad ligament the peritoneum forms the roof of the sac. In this case the blood may dissect up the peritoneum to either side of the uterus and finally raise it from the floor of the culdesac, in rare cases extending in front of the uterus also.

The contents of the sac consist then of blood in various stages of clotting and organization with some dark fluid blood. Unless hastened by operation it may require a long period for the complete absorption of this blood and usually dense masses of adhesions result. At times infection of the sac occurs with suppuration of the contents.

Sometimes the pressure becomes so great in one of these blood masses that the walls give way resulting in secondary rupture into the general peritoneal cavity with collapse.

Symptoms.—The onset is usually sudden with acute tearing pain in the lower abdomen, extreme restlessness and pallor, sighing respirations, faintness and nausea. The pulse becomes weak and rapid, sometimes almost imperceptible, and the temperature subnormal.

If the hemorrhage takes place freely into the peritoneal cavity, death may quickly follow, or the patient may rally somewhat and later succumb to recurring hemorrhage. If the bleeding is moderate, the reaction comes more promptly and the patient may quickly return to normal; frequently, however, the bleeding recurs at intervals with a return of the collapse symptoms to a greater or less extent, until finally it is checked or the patient dies from repeated loss of blood.

When the bleeding is extraperitoneal the pain and shock are usually even greater from the tearing apart of the layers of the broad ligament, but the reaction is more prompt because of the comparatively slow extravasation of the blood. A fatal issue is unusual in cases of this class.

In all of these cases when the bleeding ceases and the reaction comes, the temperature is apt to rise and may remain elevated for some weeks. An exaggerated rise in the temperature with chills, usually means suppuration.

The physical signs of blood free in the peritoneal cavity are uncertain, usually nothing can be felt distinctly until it has become clotted, when a boggy mass can be made out by vaginal examination in the retrouterine culdesac. When the blood is confined between the layers of the broad ligament, it can be felt as a boggy swelling to one or the other side of the uterus, which becomes firmer as the blood clots. The uterus is usually pushed toward the opposite side of the pelvis and often elevated until the cervix is difficult to reach.

In a large encysted swelling behind the uterus the mass can be felt to bulge down between the vagina and rectum, the uterus is crowded up behind the pubis and firmly fixed. In the recurring form, the vaginal examination reveals a swelling which enlarges at each recurrence of the symptoms.

Convalescence may be greatly prolonged in these cases by the slow absorption of the blood when the effusion is large and by the massive adhesions formed. Especially is this the case when suppuration and septicemia supervene.

Diagnosis.—This is usually easy if the onset is sudden, with sharp pain, deathly pallor and collapse. If the patient continues to sink, it is probable that free intraperitoneal hemorrhage has occurred. If, on the other hand, after collapse symptoms, the patient quickly recovers, the hemorrhage is probably confined beneath the peritoneum, or by adhesions, or is only moderate in extent. When the hemorrhage is encysted, the vaginal examination will clinch the diagnosis. As the vast majority of these cases are due to tubal pregnancy, the history of a supposed pregnancy with uterine bleeding or a decidual cast of the uterus, is of great value. When the patient is first seen, some time after the primary symptoms, and the examination reveals a mass lateral to or behind the uterus, it may be confused with pelvic inflammation. In these cases the history of the onset with the limited fever and absence of chill will favor the correct diagnosis. Puncture through the vaginal vault with a long slender needle will reveal dark bloody fluid in the one case, and often pus in the other. In ovarian cyst, the history is usually of slow development, and the aspirator gives a clear fluid.

Treatment.—When the patient is seen in the stage of acute collapse, the abdomen should be immediately opened, the source of bleeding secured, such portions of the clot removed as can be, without loss of time, and the wound closed. Salt solution should be given hypodermically or intravenously either preceding or during the operation as seems necessary. Some operators advocate leaving several liters of salt solution in the abdomen. If death is imminent when the patient is first seen, it is best to delay operation in the hope that some reaction may take place. When a definite hematocele can be made out, the patient should be kept absolutely quiet, with morphine if necessary, and will usually recover without operation. If the hematocele continues to enlarge, or if suppuration should take place, it must be drained through the vaginal vault and packed with sterile gauze.

Schauta reports from the literature 123 primary cases operated upon and 121 cases without operation, with, in the first instance, a mortality of 5.7 per cent. and in the second, 86.9 per cent., while in the hematocele cases, Thorne found it necessary to operate in only 6 of 157 cases.

PUDENDAL HEMATOCELE, otherwise called vulvar hematoma, is due to the extravasation of blood into the tissues of the labia majora or anywhere below the pelvic fascia. If the bleeding occurs above the fascia, it is called vaginal hematoma and will be considered with the vulvar form.

It may be due to a blow, a kick, or a fall, or it may follow the rupture of varices during pregnancy. It is a rare complication of labor, occurring only in about one of 1,500 to 4,000 cases. De Lee reports 5 in 20,000 cases; Winckel, 1 in 1,600 cases; Hecker, 2 in 17,200 cases, and the St. Petersburg clinics, 8 in 19,396 cases. It is more frequent in the prolonged labor of primipara. It follows the injury of vessels without laceration of the overlying tissues or may result secondarily from rupture of vessels, necrotic as the result of previous trauma, especially prolonged pressure in labor. When a vessel ruptures below the pelvic fascia, the tumor forms in one labium, spreads back to the anus and laterally, sometimes forming a tumor as large as a child's head or even larger. If the accident occurs above the fascia, the blood collects around the vaginal walls and sometimes spreads up under or into the broad ligaments. In either case, if it comes before labor it may obstruct delivery, or if after delivery, the lochia may be retained.

If the tension is very great, rupture may result with severe or even fatal hemorrhage. The amount of blood lost may be great enough to cause fatal anemia without rupture, especially in those cases that spread up into the subperitoneal tissues.

Small hemorrhages are usually promptly absorbed, larger ones may be absorbed with time, but often suppurate and may give rise to septicemia. If labor is obstructed by a hematoma, fatal rupture may be caused by pressure of the head. The previous mortality is given by De Lee as twelve to forty per cent., but with present day treatment should be much less.

The symptoms are tearing pain in the tissues, pres-

sure on the rectum and bladder, and a swelling which may come on at once or more gradually, in one of the locations described. It is usually dark colored and fluctuating, and at times very tense. If the bleeding is profuse, signs of collapse from hemorrhage also come on.

Treatment.—Ice applications should always be made and pressure if it can be effectively applied. If the mass continues to enlarge it should be incised, clots turned out, bleeding vessels caught and the whole cavity packed with gauze. The vagina should then be firmly packed and a perineal pad and abdominal bandage firmly applied.

If it is possible to wait twenty-four to forty-eight hours before incising it should be done, to allow firm clotting to occur.

Compression of the aorta may be used in some cases to control hemorrhage during operation. Small clots will be absorbed but suppuration means immediate incision. HENRY LYNDE WOODWARD.

Hematoidin.—This substance is a pigment which forms orange-colored rhombic plates in old blood extravasations. It was first observed by Virchow and it is probable that its origin is in the blood-coloring matters. Hematoidin is probably identical with the pigment of the bile—bilirubin.

F. P. U.

Hematomyelia.—Spinal Apoplexy. Hemorrhage in the spinal cord is very rare in comparison with hemorrhage in the brain. When it occurs it is usually of small extent. This is not extraordinary when the size of the organ and the firmness of its connective-tissue sheath, and the low pressure in the spinal arteries, are considered. As a rule, the clot in the spinal cord is long and narrow. It destroys a considerable part of the cord at one segment, and extends into the segments above and below, injuring these to a lesser extent. The clot is usually found in the gray matter of the cord, most frequently in the anterior horns, then in the posterior horns, and rarely in the white columns. Sometimes the surface of the cord is broken and the blood infiltrates the pia mater. Occasionally a large number of small clots are found at different levels. As the patient rarely dies at once of hemorrhage the clot is usually found in a state of decomposition, and the cord around it is infiltrated with blood cells, pigment granules, and hematin crystals. If the hemorrhage is capillary—as sometimes occurs—it is detected by the presence of pigment and crystals among the degenerated spinal elements. Around the clot the spinal cord is usually found in a state of softening, which is red in recent cases, and yellow when the process has been a long one. At a postmortem examination the question sometimes arises whether the condition found is a myelitis with secondary hemorrhage, or a hemorrhage with secondary myelitis. In the former case the microscopic examination shows a greater preponderance of granular corpuscles and leucocytes, a greater degree of degeneration in the nerve cells, and a greater extent of connective-tissue growth. Secondary degenerations upward and downward from the segment destroyed, and secondary degenerations in the motor nerves from the segment affected to the muscles, are observed after spinal hemorrhage as after myelitis. The meninges are rarely involved.

ETIOLOGY.—Spinal hemorrhage is met with in males more frequently than in females, and in youth and middle age most often. The predisposing causes are chronic changes in the general arterial system, hemorrhagic diathesis, purpura, and myelitis of the spinal cord. The exciting causes are injuries to the vertebral column and cord and extreme muscular effort, also the sudden exposure to a marked change of atmospheric pressure. The condition is often found in patients who have suffered from caisson disease. A number of cases of cervical hemorrhage have occurred from sudden bending forward of the neck.

SYMPTOMS.—As a rule, the symptoms begin suddenly, and the patient is seized in a moment with complete paraplegia and intense pain in the back at the level of the hemorrhage, and shooting pains in the body and stiffness of the spine. A spinal apoplexy usually comes without any warning, after a sudden effort. When premonitory symptoms have existed for a few days it is probable that the case is one of acute myelitis. The extent of the paralysis depends upon the level of the lesion. (See article on *Spinal Cord, Diagnosis of Local Lesions in the.*) If it is located in the lumbar or dorsal region, the lower half of the body is involved; if in the cervical region, the arms are affected as well. The hemorrhage is rarely so very limited as to affect one extremity only, but it is not frequently the case that the symptoms are more marked on one side, and in some cases the symptoms of a Brown-Séquard type have occurred. The paralysis is total, no voluntary motion is possible, the limbs are relaxed and never rigid. The muscles do not atrophy or present any change in the electric reactions, excepting those which are supplied with nerves from the segment which is destroyed by the hemorrhage. The condition of the reflex action depends upon the seat of the lesion: is it suspended at the level of the hemorrhage, and increased in the segments below it. If the hemorrhage is in the cervical region there is an atrophic flaccid paralysis of the arms and a spastic paralysis of the legs. In such a case there may be pupillary symptoms also.

If the hemorrhage is confined to the central gray matter and the patient survives, the symptoms may finally resemble those of syringomyelia. The bladder and rectum are uniformly paralyzed, and various forms of incontinence of urine and feces result, dependent upon the seat of the lesion. If this is situated high up in the cord, the viscus may empty itself occasionally, as the need arises, unconsciously to the patient and independently of his effort or control. If the lesion is low down (below the eleventh dorsal segment), there is usually retention of urine and feces, or complete relaxation of the sphincters. Cases sometimes occur of hemorrhage into the lower sacral region and conus terminalis from injuries; and in such cases there may be paralysis of the bladder and rectum only, with a small heart-shaped area of anesthesia about the anus and buttocks. Vasomotor paralysis accompanies the voluntary paralysis, and results in cyanosis and coldness of the paralyzed limbs, and predisposes the parts to the development of bedsores. The latter appear, very soon after the hemorrhage, on the prominent parts of the body which are subjected to pressure; voluntary movements to relieve such pressure, or reflex movements for the same purpose, being impossible on account of the lack of power and of sensation, for complete anesthesia and analgesia exist in the paralyzed limbs from the outset. Pain in the back, which occurs at the time of hemorrhage, does not usually presist. The danger in these cases is from the occurrence of bedsores, or of cystitis, and consequent infection from these sources, with the development of septic fever. If the hemorrhage involves the respiratory centers in the upper cervical region, sudden death takes place. This is rare.

The symptoms described are those of a severe hemorrhage, sufficient to destroy one or more segments of the cord. As a rule these symptoms gradually subside as the pressure of the clot is red emov and the only permanent symptoms are those which are due to the actual destruction of the spinal elements, viz., limited atrophic paralysis and localized anesthesia.

Dissociated anesthesia, viz., a loss of the senses of pain and temperature with preservation of the sense of touch, is not an uncommon result in the parts below the segment affected. If the clot is a small one, however, the symptoms may be more limited and less serious, partial anesthesia and localized paralysis, with atrophy, being the result. This, however, is the exception. Capillary hemorrhages give rise to widespread symptoms, which so closely resemble those of diffuse myelitis that differential diagnosis is impossible.

The PROGNOSIS is very bad in spinal apoplexy, for a destruction of the spinal elements cannot be recovered from. The patients either die suddenly, or die of complications, or linger on for months with all the symptoms of chronic myelitis. In the lighter cases they may recover sufficiently to get about, but some evidences of the hemorrhage in the form of local paralysis or areas of anesthesia always remain.

The DIAGNOSIS is usually easy, the sudden onset of total paraplegia being characteristic. In meningeal hemorrhage the paralysis is less marked than the spasms, and anesthesia is rare. In poliomyelitis anterior there is marked constitutional disturbance, with fever, before the paralysis begins, and anesthesia is not present. In acute central myelitis the onset is more gradual, the symptoms develop successively, they extend gradually to other parts, and fever is usual.

TREATMENT cannot reach the disease, but the patient should be kept absolutely quiet in the prone posture in bed, ice should be applied to the spine, and ergot should be given freely. The subsequent treatment resolves itself into care of the patient, and such measures as are used in the management of a case of chronic myelitis. M. ALLEN STARR.

Hematoporphyrin.—This is a pigment which may occur as a normal constituent in the blood of certain animals and it may be found in very small traces in human urine. After the use of sulphonal relatively large amounts may be found in the urine. By reduction of hematin hematoporphyrin is formed and the latter may be regarded as iron-free hematin. There is also a very close relationship between this pigment and chlorophyll. It is probable also that hematoporphyrin is isomeric with the bile-pigment bilirubin. An acid alcoholic solution of of hematophyrin shows two absorption bands, one lying between C and D and the other between D and E. A dilute alkaline solution of hematoporphyrin yields four absorption bands, a band between C and D, a second broader band surrounding D and with the greater part between D and E, a third between D and E, nearly at E, and finally a broad dark band between b and F. A regeneration of hematin from hematoporphyrin is said to be possible. If hematoporphyrin is dissolved in dilute ammonia and warmed with Stokes' solution and hydrazine hydrate, iron is taken up again and hemochromogen is produced which is transformed into hematin by shaking with air. FRANK P. UNDERHILL.

Hematoxylon.—LOGWOOD. *Campechy Wood.* The heart wood of *Hematoxylon campechianum* L. (fam. *Leguminosæ*) U.S.P. This is a small, spreading, irregularly branched tree, with a dark rough bark on the trunk and larger branches, and light-brown, white-spotted twigs. Wood hard and close, divided into a light colored alburnum and a red heart wood, the whole of the former being rejected. It is a native of Central America, especially of Honduras and Yucatan. It takes one of its names from Campeche. It is also naturalized and cultivated in the West Indies, where it grows freely.

It is supposed that logwood was used by the aborigines for dyeing before the arrival of Europeans, but this is not known with certainty. It was, however, imported into England in the latter part of the sixteenth century, and shortly after interdicted for a time as yielding poor and fading colors. It was introduced into the London Pharmacopœia about a hundred and fifty years ago.

When first cut, the heart-wood is of a light-red color, but by exposure to the light and air it becomes dark-brown, and finally almost black upon the surface, sometimes dark-bronze and iridescent. The inside becomes, in time, of a rich reddish-brown. In the course of manufacture it is cut, by heavy machines with rapidly revolving knives, into fine chips, in which condition, or in powder, it is purchased for pharmaceutical purposes. For dyeing purposes these chips are cured by soaking them in water and then frequently turning them over to expose them to the atmosphere. The chemical changes which ensue largely unfit them for medicinal use. Such chips are distinguished by their dark or blackish metallic green or blue surface. Logwood has a sweetish astringent taste and colors the saliva pink.

Logwood contains about ten per cent. of a sweet-tasting, crystalline coloring substance, *hematoxylin*, readily soluble in hot water or alcohol, but nearly insoluble in cold water. It turns red upon exposure to sunlight, and gives violet solutions in the presence of alkalies and air, due to the formation of *hematein*. Melted with potash, it yields pyrogallic acid.

ACTION AND USE.—This substance is infinitely more used in the arts than in medicine, being an important dye and foundation for inks. In microscopical work, the purple solution of extract of logwood, or hematoxylin, is a favorite stain, acting with great rapidity and bringing into prominence the nuclei of cells. As a medicine, it is a mild and rather agreeable astringent, useful in subacute diarrhea of children and in phthisis, but no better than a dozen other astringents, except that its taste commends it to children. The linen is very liable to be stained red when it is used. The extract is official (*Extractum Hematoxyli*, U. S. P.), made by exhausting with boiling water and evaporating to solidity. H. H. RUSBY.

Hematuria may be defined as the presence of blood cells in the urine from any cause.

If blood is present in small amounts only, the urine shows no change in color or macroscopic appearance.

If the amount is greater, the color varies from a slight smokiness to a deep red or dark brown. The sediment macroscopically shows a decided red or brown tint. Clots are occasionally seen, sometimes showing distinct moulding by the ureter or pelvis of the kidney. Under the microscope, the red cells are found in different states, according to the character of the urine. In a urine of low specific gravity, the cells are often found to be swollen and very faint in color, due to the partial laking of the blood by the very dilute fluid.

If the urine is concentrated, the cells appear normal, or at times crenated because of the abstraction of water by the concentration of the fluid. They may appear alone or be accompanied by other organized sediments as epithelial cells, pus cells, mucus, and casts, or unorganized sediments as phosphates, especially in alkaline urine.

At times the blood cells are separate and scattered; again, together in clumps or small clots and sometimes adherent to casts, forming the so-called blood casts. The different varieties may be designated by the source of the blood and the cause of the bleeding. The blood may come from either kidney, from the pelvis, the ureter, the bladder, the urethra, and at times from outside contamination as from the uterus during menstruation or in the case of a malingerer.

The kidney and the bladder are by far the most frequent sources and often the character of the urine, and the condition of the blood in it, are diagnostic of the situation from which it comes. When renal in origin it is always thoroughly mixed with the urine and the urine when passed is usually acid. The color is usually dark brown because of prolonged contact with the urine, unless the flow of blood is profuse, when it is bright red. Casts of the renal pelvis and ureter are conclusive proof that the bleeding is renal or from the pelvis of the kidney.

When the bleeding is vesical it is usually bright red unless the urine is retained for long periods, when it may be dark. When the bleeding is considerable, the blood is thoroughly mixed with the urine, but when small in amount it may only be found in the last portion of urine and the earlier portion be entirely free. When the fresh urine shows signs of ammoniacal decomposition it indicates that the cause of the bleeding is also causing a cystitis and the blood is accompanied by mucus, pus cells, bladder epithelium, and triple and amorphous phosphate deposits. In renal hemorrhage, the affected organ can be determined by the cystoscope and various separators.

The causes of bleeding may be general diseases, especially the infections, when in a malignant form. The purpuras, leukemia, hemophilia, scurvy, and morbus maculosus (Werlhof).

Renal Causes.—Congestion of the kidney, whether acute or chronic, may give rise to hemorrhage, also nephritis in all its varieties, but especially the acute forms including those due to drugs. Malignant disease of the kidney, tuberculosis, calculus, cystic degeneration and certain parasites, are also causes.

Calculus, tuberculosis, severe inflammations, malignant or other growths, or parasites may cause hemorrhage from their location in any portion of the urinary tract.

Trauma of any portion of the tract from kidney to meatus urinarius may be accompanied by hematuria.

Gull's renal epistaxis is also a cause in which no definite lesion has been demonstrated.

The hematuria occurring in general diseases is usually accompanied by hemorrhages in other parts of the body as the petechial or ecchymotic patches occurring under the skin in purpura, leukemia, the hemorrhagic forms of the acute infections and so on, or by bleeding from the gums and under the periosteum as occurs in scurvy.

The bleeding from the kidney in these diseases is due to severe acute congestion or more commonly acute diffuse nephritis. The diagnosis depends upon the general symptomatology of the disease in question.

Hematuria due to acute active congestion of the kidneys is infrequent. Usually if the congestion is severe enough to give rise to hemorrhage, it has gone beyond simple congestion and is really an inflammation of the kidney. Chronic congestion of the kidney is, however, a comparatively frequent cause. This is usually due to the damming back into the kidneys of the blood from the vena cava and renal veins which is associated with cardiac insufficiency, or thrombosis within or pressure upon these veins.

Nephritis in its various forms is probably the most common cause of hematuria. It is especially likely to occur in the very acute attacks of nephritis that come in the acute infections already mentioned, in the form which so frequently follows scarlet fever and after the use of certain drugs, turpentine, cantharides, potassium chlorate, and various phenol derivatives. One of the most severe and prolonged cases of hematuria I have ever seen was caused by the inhalation of turpentine fumes, by a carriage painter, while working in a close room. The lesion was a very severe acute nephritis. In chronic interstitial nephritis, hematuria does not often occur except in the presence of an acute exacerbation, but in the parenchymatous form it is quite common and Wiegert claims that the amount of bleeding is a good indication of the severity of the process.

In the hematuria of nephritis, the blood is well mixed through the urine, and with it are found casts of various kinds, most characteristic of which is the blood cast. Hyaline casts are also found with blood in severe congestions but usually the other forms of casts are absent.

New growths in the kidney, particularly the malignant forms give rise to hematuria. Carcinoma, sarcoma, and hypernephroma, all of which may be first suspected by the occurrence of profuse hemorrhage are often accompanied by clots in the form of casts of the renal pelvis or ureter. Clots of this form rarely occur except in the hemorrhage from malignant growths. Very rarely portions of the growth have been found in the urine in a sufficient state of preservation for sectioning and the diagnosis has been made directly in this way. At times the hemorrhage is so profuse as to be passed as almost pure bright red blood. Ultimately the diagnosis must rest upon the discovery of the enlargement of the kidney, localized pain, etc.

Malignant or other bladder tumor may be first suspected because of bleeding which occurs without known cause. It often comes on suddenly and may stop suddenly, the last portion of urine passed often contains more blood than the first, the color is usually bright red and passing an instrument will often increase the bleeding. At times the bleeding is very severe and may last a long time. A curious condition known as fibrinuria (Ultzmann) may occur in these cases, the urine clotting after being passed, due to the presence of blood plasma without blood cells in any number. This is probably due to a contraction pressure upon the growth, sufficient to squeeze out the plasma without true hemorrhage. As with renal tumors, the diagnosis is sometimes made certain by the passage of tumor fragments which can be sectioned. Here also the cystoscope is a great help.

Kidney tuberculosis may cause bleeding in an early stage if the papillæ are involved or later when ulceration has occurred. Usually the bleeding is not profuse in the start, but later it sometimes resembles that of malignancy. Tubercle bacilli are usually to be found in the urine if repeated search is made.

Bladder tuberculosis is almost always associated with renal or genital tubercular troubles and it can only be certainly determined that the blood is due to bladder involvement when the urine shows a constant deposit of pus with tubercle bacilli and when urination is accompanied by tenesmus and the sound or catheter produces pain at a certain point in the bladder. The cystoscope will often clear the diagnosis.

Nephrolithiasis gives rise to bleeding which may be considerable in extent, but is usually intermittent, being more apt to occur after exercise or where an attempt has been made by a small stone to pass the ureter.

The associated colicy pain, referred to groin and testicle is characteristic unless a clot has been passed through the ureter sufficiently large to cause obstructive pain. When the stone is too large to pass the ureter, the bleeding will be accompanied by pain in the loin and this also is accentuated after exertion.

Vesical calculus is a frequent source of bleeding, which is increased on exertiou, as is also the associated pain. Pain referred to the end of the penis and sudden stoppage of the flow of urine are very significant and are checked up by the sound and cystoscope.

Polycystic degeneration of the kidney and other cysts are often associated with hematuria which is usually slight in amount. Infarct of the kidney due to embolus also gives rise to bleeding at times.

Trauma, either from instrumentation which is unduly severe and prolonged, or from external injury usually gives a clear history which is of diagnostic value. The bleeding may be very slight and transi-

tory as in the capillary hemorrhage, due to slight injury over the kidney or severe and prolonged after-rupture of the kidney or bladder.

Parasitic hematuria is endemic in certain tropical countries, Egypt and Cape Colony in Africa, India, Brazil, and the Islands of Mauritius and Reunion.

The usual parasite is the blood fluke *Schistosomum hæmatobium* but the *Filaria bancrofti* with the echinococcus and strongylus are occasional causes.

The *Schistosomum hæmatobium* was discovered by Bilharz in 1851 as the cause of the hematuria endemic in Egypt and the neighboring countries.

The parasite has the sexes separate, thus differing from other flukes. The female is usually carried in the gynecophorous canal formed by a ventral incurving of the lateral borders of the male. The male is 12 to 14 millimeters long, while the female is about 20 millimeters. The eggs are oval 0.16 by 0.06 millimeters with a spine at one end or laterally near the end. The mode of infection is not known, whether by mouth, urethra, or through the skin. It may enter the body in water, on cresses, etc., and find its way to the veins, especially the portal vein and those of the bladder and rectum. The eggs are deposited in the tissues and wander into the mucosa of the bladder and rectum and can be found in the urine and feces.

Hematuria is a fairly constant symptom of this disease and it is due to the changes in the bladder mucosa caused by the parasite and eggs. The bleeding may be the first symptom and recurs for months and years without affecting the general health or may produce anemia of a moderate grade.

In some cases no other symptoms are produced but often vesical or rectal irritation and dull pain in the perineum are associated with the hematuria. At times severe cystitis and proctitis result or even the formation of papillomata in these organs. In the bladder these may become encrusted with salts and aid the formation of calculi. The ovum is sometimes found as the nucleus of a stone.

Periurethral abscess and perineal fistula often occur in chronic cases. Chronic vaginitis sometimes results. The parasites in the portal system may produce no symptoms but at times a marked thickening of Glisson's capsule results in advanced hepatic cirrhosis of this type.

The diagnosis of the cause of the hematuria is made by finding the ova in the urine.

The *Filaria bancrofti* is the cause of hematochyluria. The adult male is about four centimeters long and the female about eight centimeters. They are thread-like and live in pairs in the lymphatics, especially of the groin and pelvis. They are often present in sufficient numbers to cause lymphatic obstruction and give rise to elephantiasis and lymph scrotum.

In Samoa, the West Indies, Central America, Panama, and the southern United States, they abound. The female produces large numbers of embryos which at night migrate into the circulating blood. These embryos have the width of a red cell and are 0.2 to 0.4 millimeters long, they are very actively mobile. About midnight they are most numerous in the blood and their number has been estimated in one case at 2,100 per cubic centimeter of blood (Lathrop and Pratt). By ten o'clock the next morning they were gone. They can be found at other times in lymph and sometimes in the urine.

Often without any interference with the general health, these patients will pass urine of a milky whiteness or blood stained which on standing settles in three layers, a bloody clot, then urine, and on top a fatty layer. This upper layer is cleared by shaking with ether. This is probably due to the rupture of dilated lymphatics in some portion of the urinary tract which in turn depends on the blocking of larger lymph vessels by the parasites. These attacks are intermittent and some of these patients pass normal urine for months at a time. This condition may go on for years without serious disturbance to the general health of the patient. Osler reports a case that had hematochyluria intermittently for eighteen years, with inconvenience only in passing clots collected in the bladder and some uneasy sensations in the lumbar region.

Echinococcus may give rise to hematuria when it involves the kidney or bladder and at times the diagnosis is made by the passage of portions of membrane or small cysts in the urine.

A strongylus is also mentioned by Dieulafoy as a cause of hematuria, especially in Brazil.

Essential hematuria is a form in which no demonstrable lesion of the kidney can be made out, it is also spoken of as renal epistaxis (Gull), angioneurotic hematuria, and renal hemophilia. The surgeons have demonstrated the existence of this form of bleeding by exploratory operations for possible tuberculosis, new growth, or stone in which no lesion could be found.

The patients are usually young, at least below middle age and the bleeding comes on spontaneously, sometimes without pain, but often with pain. It is usually unilateral, but both organs may be involved. The bleeding ceases of itself and rarely is severe enough to cause marked anemia. At times the exploratory nephrotomy will cure the disease entirely, how it is impossible to say.

The diagnosis can be had only by exclusion and often is not definitely settled till after exploration.

Treatment.—It is difficult to designate, even in outline, the treatment of a condition which is a symptom of so many diseases. It is essentially the treatment of the various causes, which are taken up under their appropriate sections.

There is, however, need in many cases for treatment of the symptom itself because of severe or long-continued hemorrhage and blocking of the passages by clots.

Hemorrhage is best controlled by rest in bed and ice caps to the loin or hypogastrium according to the location of the hemorrhage. Diluent drinks, milk, buttermilk, and large quantities of water should be given to dilute the urine and prevent clotting as far as possible. If the bleeding is excessive and accompanied by restlessness and tenesmus, morphine should be given to quiet the patient. If clots cause retention, a catheter can be tied in.

Among internal remedies may be mentioned acetate of lead and opium in full doses, calcium lactate, adrenalin, ergot or ergotine, tannic acid, gallic acid, hamamelis, and hydrastis.

If the bleeding is from the kidney, dry cups to the loins may be tried, or in the case of renal epistaxis, splitting the kidney has frequently caused relief.

When the hemorrhage is vesical, local applications can be made of hot astringent solutions, adrenalin chloride, 1 to 5,000, silver nitrate 1 to 2,000 or hydrastis, an ounce to the pint.

Antipyrin in five per cent. solution is valuable to allay pain and also as a hemostatic. All bladder manipulations must be made with strict aseptic precautions, as the bladder is very susceptible to infections after hemorrhage and this may easily spread to the kidneys.

Henry Lynde Woodward.

Hemeralopia.—This term means properly day blindness, although it is often incorrectly used, in place of nyctalopia, to express day vision, or night blindness. Hemeralopia is an affection or symptom implied by the name (ἡμέρα, day, ἄλαος, obscure, ὤψ, eye) in which the patient sees better on dark or dull days, or in the dark than in a bright light. In these cases the field of vision is not concentrically contracted. The condition may be congenital, as in

coloboma of the iris, irideremia, and albinism, or may occur in amdyopia from tobacco or alcohol, and in affections of the optic nerve and some diseases of the retina.

There is also a pronounced class in whom great sensibility to light is a prominent symptom, which may be called hyperesthesia retinæ. It is found in both sexes, and usually follows some illness; in many cases it is of an hysterical nature.

The action of a dazzling light or the action of heat on the pigmented parts of the fundus may cause this hyperesthesia. Thus it may follow looking at an eclipse of the sun without a smoked glass, or, in the case of a stoker, looking into the furnace, or long exposure to strong electric light, or to sunlight on snow, as in the arctic regions. There are no changes in the interior of the eye.

The treatment consists in protecting the eyes by colored glasses, gradually accustoming the patient to ordinary light and building up the general system, if not in proper condition, with reconstructives and tissue builders. (See *Nyctalopia.*)

William Oliver Moore.

Hemianopsia.—This is a condition of blindness limited to one-half of the visual field. *Hemiopia* is used as a synonym incorrectly, as it signifies vision (not blindness) in one-half of the visual field. This condition may be present in either the outer (temporal) or inner (nasal) half of the field of vision, and may affect one eye alone or both eyes. If both eyes are affected like-named halves of both may be involved—*e.g.* the left half of both eyes, in which case the condition is called *homonymous hemianopsia;* or unlike-named halves of both eyes may be involved—*e.g.* the left half of the left eye and the right half of the right eye, in which case the condition is known as *heteronymous hemianopsia.*

evident from this figure that the loss of one nasal half of the visual field is not appreciated by any one unless the unaffected eye is closed. This fact is of importance, as it is evident that a nasal hemianopsia is a symptom which may not be noticed by a patient, and hence must be looked for by the physician. The unequal size of the two portions of each visual field is so marked that in an homonymous hemianopsia the patient usually ascribes the blindness wholly to a defect in the eye whose larger portion is affected, and a careful medical examination is necessary to establish the existence of a bilateral affection.

To determine a patient's visual field, each eye is to be tested separately. The patient holds a card before one eye and looks the examiner in the eye with the other. Any object, preferably a white one, is then moved about in the visual field of the eye which is uncovered, and the power and extent of indirect vision is thus determined. If hemianopsia exists the patient will be unable to see the object when it is within the field of vision which is defective, or when it is carried beyond the vertical line passing through the fixation point toward the defective side. More accurate measurements may be made by means of a perimeter, but the method described is sufficient to establish the existence of blindness in one-half of the visual field. In no case of hemianopsia is direct vision at the fixation point affected.

Since the lens of the eye reverses the image of the object seen upon the retina, each half of the visual field corresponds to the opposite half of the retinal expansion. A hemianopsia therefore indicates a suspension of function in the half of the retina opposite to the defective visual field. Such a functional derangement of one-half of the retina is rendered possible by the origin, course, and distribution of the nerve fibers in the optic nerves, as seen in Fig. 3120. Each optic nerve is seen to pass from the eyeball back to the optic chiasm and there to divide into two parts.

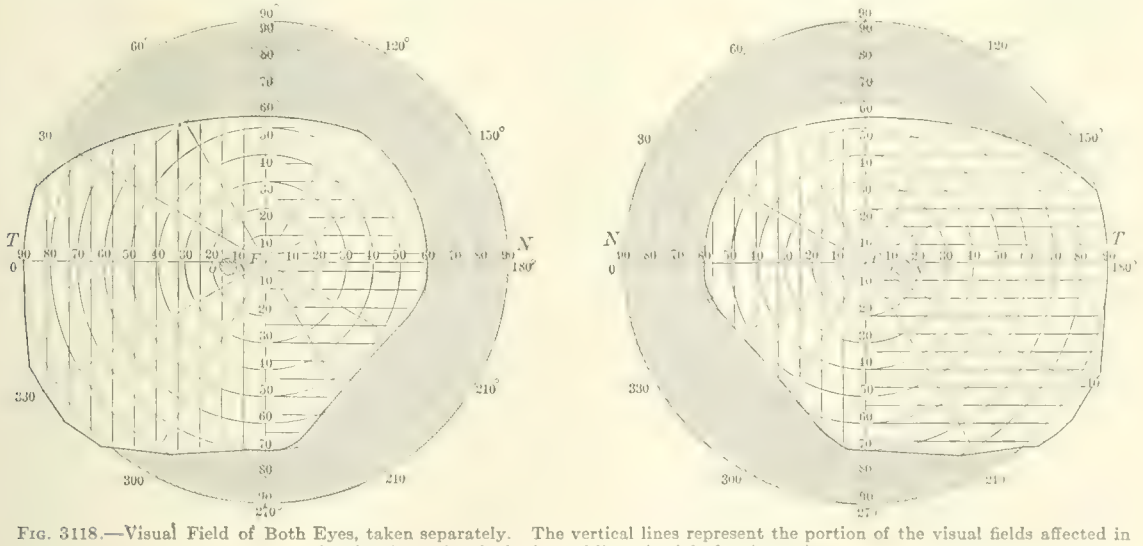

Fig. 3118.—Visual Field of Both Eyes, taken separately. The vertical lines represent the portion of the visual fields affected in left hemianopsia; the horizontal lines, in right hemianopsia

By means of Förster's perimeter the visual field of each eye has been determined (Fig. 3118). It is found to have an irregular outline, and to be divided into a large outer and a small inner portion by a line drawn vertically through the point of fixation. This point corresponds with the macula lutea, and lies on the outer side of the entrance of the optic nerve. The two inner fields really overlap one another, so that the actual outline of the entire visual field of both eyes is that represented in Fig. 3119. It becomes

One of these turns outward and joins the optic tract of the same side. The other crosses the median line in the chiasm, decussating with its fellow from the opposite optic nerve, and joins the optic tract of the opposite side.

The anatomical separation of the fibers from one optic nerve renders it possible for a lesion situated in the chiasm, or in the optic tract, to affect a portion of the fibers coming from one eye, and consequently a part of the retina; while a lesion affecting the optic

nerve itself involves necessarily the entire extent of the retina, producing amaurosis, not hemianopsia. It is found that the portion of the retina lying to the outer side of the fixation point is joined with the fibers of the optic nerve which pass directly into the optic tract of the same side; while the inner portion of the retina sends its fibers across the median line in the decussation (Fig. 3120). It has been already shown that the nasal portion of the retinal expansion, corresponding to the temporal half of the visual field, is larger than the other portion. The number of fibers in the optic nerve which decussate is greater than the number which do not cross the median line. The ratio of non-decussating to decussating fibers in the optic nerve, in any animal, is directly proportionate to the extent of the visual field common to both eyes. Thus in the horse, or the rabbit, in whom there is no part of the visual field which is common to both eyes, the decussation of the optic fibers is total. In dogs, cats, monkeys, and man, in whom, to a less or greater degree, the eyes are directed in parallel lines, the decussation is partial. In a rabbit or horse hemianopsia is impossible. In the other animals named it is observed.

Unilateral hemianopsia is produced by lesions affecting the optic chiasm only. If the lesion lies on the outer side of the chiasm it produces nasal hemianopsia on the side of the lesion. Thus a tumor pressing upon point *N* in Fig. 3120 would produce blindness in the temporal half of the left retina, and hence nasal hemianopsia in the left visual field. If the tumor lies in front of or behind the chiasm, or presses upon it from above or below in such a manner as to involve the decussating strand of fibers either before or after they have crossed to the opposite side, it will cause a temporal hemianopsia (*T* in Fig. 3120). As it is impossible to determine whether the fibers are affected before or after decussation, no statement as to the side upon which the lesion lies can be made. This symptom is often observed in tumors of the hypophysis.

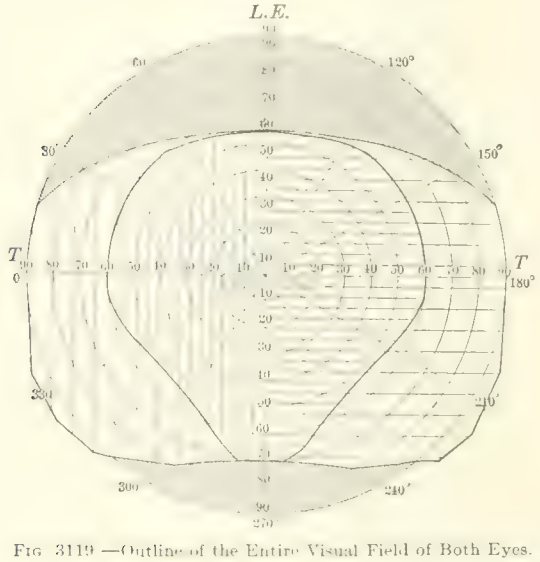

Fig. 3119.—Outline of the Entire Visual Field of Both Eyes.

Bilateral hemianopsia is far more common than unilateral. It may be of several varieties. Bilateral nasal hemianopsia implies a destruction of the direct optic fibers on both sides, the decussating fibers being unaffected. Such a case has been observed by Knapp, in which a tumor surrounded the chiasm, pressing upon its sides, but not affecting its center. Bilateral temporal hemianopsia is a rare condition, and is produced only by a lesion which divides the chiasm through its anteroposterior diameter without affecting its lateral halves, thus destroying both decussating strands. It has been observed in a few cases of tumor of the hypophysis.

Bilateral homonymous hemianopsia is a not uncommon condition, and may be produced by many causes, and by lesions situated in many various parts. This will be better understood after the course of the optic tracts has been followed to their terminations in the visual area of the cerebral cortex (Fig. 3120), since a lesion at any point in this course will produce the

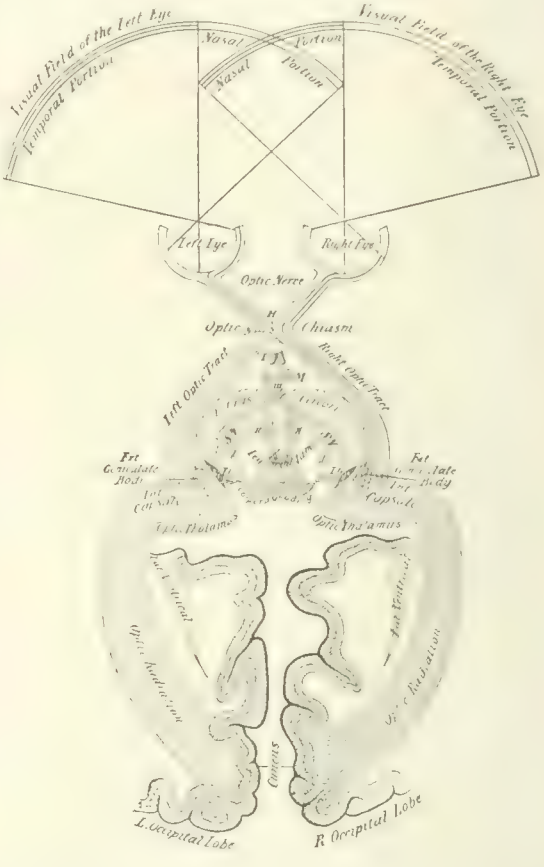

Fig. 3120.—The Visual Tract. The result of a lesion anywhere between the chiasm and cuneus is to cause homonymous hemianopsia. III. Third nerve; S. N., substantia nigra; R. N., red nucleus of tegmentum; L., lemniscus; T. G., fibers from optic tract to corpora quadrigemina.

symptom named. Each optic tract, after leaving the chiasm, passes around the crus cerebri, lying directly upon the fibers which pass through the foot of the crus (pes pedunculi), and ends on the level of the tegmentum of the crus in the external geniculate body, in the pulvinar of the optic thalamus (*i.e.* the eminence forming its posterior surface), and in the corpora quadrigemina anteriora, which latter it reaches by the brachium conjunctivum. The last-named fibers of the optic tract have probably nothing to do with conscious vision, and may therefore be excluded from consideration in studying hemianopsia. They form the sensory part of a reflex arc, whose motor part is made up of the motor nerves to the eyeballs. The functions of this reflex mechanism are to direct the motion of the eyeballs, and to regulate the process of accommodation and the size of the pupil. The primary visual centers are, therefore, the external geniculate body and optic thalamus. The fibers of the optic tract end in fine brushes which terminate about the cells of these ganglia, and from these cells

new fibers arise which collect in a large tract and issue from the posterior external angle of the optic thalamus into the posterior third of the internal capsule. This visual tract turns upward and backward in the internal capsule, radiates into the centrum semi-ovale of the occipital lobe, and, passing around the outer border of the posterior horn of the lateral ventricle, terminates in the convolutions of the cuneus. At no point in this course is any decussation found. The only decussation of fibers between the eye and the cortex is in the optic chiasm.[1]

Bilateral homonymous hemianopsia may be caused by a destructive lesion lying anywhere in the course of these fibers between the optic chiasm and the cuneus or by a lesion in the cortex which destroys the perceptive centers in which the fibers end. Wherever the lesion, the character of the symptom will be the same. From the accompanying symptoms, it is in some cases possible to locate the lesion causing the hemianopsia. Thus, if the optic tract is involved as it curves around the crus cerebri, the same lesion which causes the hemianopsia will be likely to affect the motor tract in its passage through the pes, or to involve the third nerve in its exit from the pes. In this case hemianopsia and hemiplegia of one side, with oculomotor paralysis of the other side, will be combined. Or, if the termination of the optic tract in the geniculate body and thalamus is involved the lesion, unless extremely limited, will affect the sensory tract from the opposite side of the body in its passage through the tegmentum of the crus, or in the posterior portion of the internal capsule, and in this case hemianesthesia and hemiataxia will be associated with hemianopsia. Or, if the visual tract in its passage through the internal capsule is involved by disease in the basal ganglia or in the capsule, the proximity of both sensory and motor tracts in the capsule will render a combination of hemianopsia, hemianesthesia, and hemiplegia quite probable. This is the seat of the lesion, and this is the combination of symptoms most frequently observed (see *Brain, Diagnosis of Local Lesions*).

Lesions in the centrum ovale involving the optic radiation may not produce any other symptom than that under discussion. If it is the left hemisphere, however, in which the disease is present, a condition of mind-blindness, an inability to recognize objects formerly familiar and of word-blindness (see *Aphasia*) is not infrequently associated with it, and in all the cases of mind- and word-blindness hitherto reported hemianopsia has been found. This is probably due to the destruction of association fibers between the occipital and temporal lobes which lie side by side with the visual tract.

Lesions in the cortex of the cuneus produce no other symptom than hemianopsia. But small lesions of the cuneus may cause small defects of a bilateral kind in the visual field. Thus a small lesion in the upper part of the cuneus has been known to cause a bilateral hemianopsia in the lower quadrant of the visual field (cases of Hun and of Henschen) and lesions in the lower part of the cuneus have caused upper quadrant hemianopsia (cases of Uthoff and Haab).

Lesions in the angular gyrus may produce hemianopsia. It is probable that such lesions have caused the symptom by affecting the visual tract as it passes beneath this gyrus in the centrum ovale. There is no reliable evidence that a unilateral lesion in the cortex can produce blindness of one eye alone.

Hemianopsia is, therefore, a local symptom of brain disease of great value in determining the situation of a lesion, when considered in connection with other symptoms. The symptom alone affords little evidence of the nature of the disease producing it, since it may be caused by any of the various forms of brain lesion (see *Brain*). It has been observed in cases of basilar meningitis, in tumors of the occipital lobe and basal ganglia, in hemorrhage and softening involving the internal capsule, and in embolism of the terminal branches of the posterior cerebral artery, and of the trunk and posterior branch of the middle cerebral artery, as well as in other rarer conditions.

The diagnosis of the symptom may be made by an examination such as has been described. The prognosis and treatment of it will depend entirely upon the nature of the disease producing it.

M. Allen Starr.

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Hemicelluloses.—Under this term are included those carbohydrates that are insoluble in water and resistant to the action of diastase, never being changed by it into sugar. They are distinguished from cellulose by being capable of hydrolysis on boiling with dilute mineral acids. According to the kind of sugar yielded on hydrolysis, the hemicelluloses are designated as pentosans or hexosans, the latter including galactans, mannans, dextrans, levulans, etc. The seaweeds in general are particularly rich in hemicelluloses. Investigation has demonstrated that although these substances, when fed may disappear from the alimentary canal, they probably are of little value as sources of energy for the organism, their disappearance being due chiefly to the action of alimentary microorganisms. F. P. Underhill.

Hemidesmus.—Hemidesmus Radix. *Indian Sarsaparilla.* "The dried root of *Hemidesmus indicus* R. Br." (B. P.) (Fam. *Asclepiadaceæ.*) The plant is a slender, twining shrub, native of India. The description in the British Pharmacopœia, into which it is introduced apparently out of compliment to the Indian physicians, is as follows: "The root is long, rigid, nearly cylindrical, tortuous and longitudinally furrowed. It seldom exceeds ¼ of an inch (6 mm.) in thickness and is of a reddish-brown or dark-brown color. On one side of the root the cork is frequently separated from and raised above the cortex, and is transversely fissured. The transverse section exhibits numerous lactiferous cells in the cortex. The root has a fragrant odor and a somewhat sweet taste." A syrup, made from one ounce of hemidesmus to ten and one-half ounces of menstruum, is used in England.

The medicinal properties of hemidesmus are said to be those of sarsaparilla, in the stead of which it is used in British India; in Europe or in this country it is rarely used. Its composition has not been fairly studied, but it is safe to say that nothing physiologically very peculiar or active is contained in it. An odorous principle, perhaps cumarin, has been partially examined. The syrup prepared from it, like that of sarsaparilla, is scarcely more than a flavoring vehicle.

Henry H. Rusby.

Hemin.—This substance may be regarded as the hydrochloric acid ester of hematin. By the action of acids upon hemin the pigment hematoporphyrin may be formed. Hemin crystallizes in microscopic rhombic crystals which serve as the basis for the identification of blood. The crystals are insoluble in water, dilute acids at the normal temperature, alcohol, ether and chloroform. They are slightly soluble in glacial acetic acid on the addition of heat. They dissolve in acidified alcohol and also in dilute caustic alkalies or carbonates. F. P. U

Hemiplegia.—By hemiplegia we understand paralysis of one side of the body, the arm and leg being

affected with or without the face. While this condition may be caused by a half-sided lesion high up in the spinal cord, in or above the cervical enlargement, such a localization is very rare. In nuclear lesions in the spinal cord—from poliomyelitis—the leg and arm on the same side are occasionally affected though rarely without at least some trace of trouble on the other side and a neuritis affecting the nerves of the arm and leg on one side only is at least theoretically possible, though rarely if ever found. In the vast majority of cases, however, hemiplegia is due to brain disease on the side opposite to that of the paralysis. Since the muscles of one side of the body have their representation in the cortex about the fissure of Rolando on the opposite side of the brain a lesion affecting this area would, and sometimes does, cause hemiplegia, but since for complete one-sided paralysis a very extensive lesion is necessary, the prevailing type of paralysis from cortical injury is that of one limb (or of the face), a monoplegia. Similarly, in the centrum ovale beneath the cortex, the fibers run far apart and it is only in their passage through the internal capsule that they lie so close together that a small lesion—not much bigger than a pea—can destroy the fibers for face, arm and leg and set up a paralysis of the whole opposite side of the body. The great majority of cases of hemiplegia are due to lesions at this point, and for some reason, a small artery—the lenticulo-striate—entering the brain in the anterior perforated space and supplying this region, seems peculiarly prone to rupture, so much so that it was called by Charcot, "the artery of cerebral hemorrhage."

The motor fibers may equally well be affected in their course through the crus, in the pons, and in the medulla where they finally decussate and cross to the other side.

Etiology and Pathology.—The majority of cases of hemiplegia are due to vascular troubles, hemorrhage, embolism, and thrombosis. In persons of middle and advanced age brittleness of the arteries and disease of their tunics often with the development of miliary aneurysms favor their rupture, and high blood pressure may be a determining factor. On the other hand arteriosclerosis and atheroma may cause a gradual encroachment upon the lumina of the vessels, and favor clotting of the blood (thrombosis), so that the territory supplied by the affected vessel is gradually deprived of its blood supply and undergoes softening. In younger subjects syphilitic arteritis may cause weakening of the vessel walls or obliteration of the lumen, while at any age an endocarditis may give origin to an embolus which is arrested in a brain artery causing sudden cutting off of blood supply and if in the proper place, hemiplegia, while in acute infectious disease, changes in the vessel walls and in the blood may favor thrombosis. In young subjects, in the absence of these latter factors, a hemiplegia coming on suddenly is nearly always of syphilitic origin. The rupture of an artery or the sudden cutting off of blood supply, usually causes disturbances of consciousness more or less profound which together with the resulting paralysis give the chief symptoms of apoplexy. Other causes of hemiplegia are direct pressure by depressed bone or blood clot, brain tumor, abscess, meningitis and encephalitis, and hydrocephalus. Hemiplegia may also be a manifestation of hysteria.

Symptoms.—In the majority of cases hemiplegia follows an apoplectic attack or "stroke." The weakness of the affected side, however, may be apparent from the start, the patient if not profoundly unconscious, being noticed to move the sound side only, movements of defence in response to a painful stimulus being lacking upon the affected side. Even where there is no movement a difference in the muscular tonus of the two sides will often be found, the paralyzed limbs when raised, falling down by dead weight, while those on the unaffected side sink gradually to the bed. If the lesion is in the cortex the limbs later paralyzed may be convulsed at the start. There is nearly always some drawing of the face toward the sound side and in cases in which the unconsciousness is prolonged, contracture of the limbs on one side indicates a hemiplegia. While the pupils may be dilated in cerebral hemorrhage and it is stated (Starr) that the one on the side of the hemorrhage is apt to be the wider, in general the eye muscles are not affected except in lesions in the crura or about the corpora quadrigemina. The upper facial muscles also escape. The tongue as a rule deviates toward the paralyzed side. There may be some difficulty in swallowing at the start but this usually disappears by degrees. As consciousness fully returns the paralysis of the affected side becomes apparent. It is of the spastic type, the tendon reflexes, which may be absent during the coma and shock, become exaggerated, the knee-jerk is greatly increased, an ankle clonus may be obtained, and the pathological reflexes of Babinski (extension of the great toe upon irritating the sole) and Oppenheim (the same result from stroking firmly the inside of the tibia) are present upon the paralyzed side. The arm reflexes may also be greater upon the affected than upon the normal side. The skin reflexes are lost upon the paralyzed side. The altered reflexes persist even after the paralysis has improved. Control of the bladder and rectum are lost during the coma and may persist for a long time. After the immediate effects of the stroke have disappeared, the paralysis gradually improves and the case enters upon the chronic stage. The patient usually begins to regain some power in the leg, is able to draw it up, then to flex the ankle and move the toes, improvement in the use of the arm and hand gradually following. The finer movements of the hand are regained more slowly and may never fully restored. How complete the recovery is depends upon the amount of destruction which there has been. The involvement is most profound at the start, since even though the hemorrhage may be small, there is edema of the adjoining parts of the brain, which later subsides, and the actual destruction may be small. The permanent disability is apt to be most marked in the arm and this is more liable to contracture than the leg. These contractures tend to fix the arm in a position of flexure at the elbow, the wrist pronated and flexed, the fingers closed, while the leg tends to be rigidly extended. They are a very unfortunate sequel of hemiplegia, increasing the functional disability. The extensors of the foot and the flexors of the leg are paralyzed to a greater extent than the other muscles so that the knee cannot be flexed in walking and the foot tends to assume the equinus position. On account of these disabilities, the gait of the hemiplegic is typical. The affected side is held rigidly seeming to move forward all together and there is a droop of the shoulder, the arm is held tightly flexed, the elbow against the side, while the leg is dragged forward as a whole and swung outward in the arc of a circle, the toe and inner side of the ball of the foot sweeping the ground so that the shoe wears on that side.

Where the paralysis is not too profound, the patient may learn to overcome the difficulty in advancing the leg by lifting it high, flexing the thigh on the trunk. The stiffness may be severe enough to be painful. In some cases particularly in the hemiplegias of children, there develops in the muscles of the paralyzed limbs, more particularly in the fingers, slow involuntary movements of flexion and extension which have been given by Hammond the name of "athetosis." These athetoid movements may extend to the elbow and shoulder and are more rarely observed in the foot and in the face. Hemitremor and hemichorea are also seen occasionally. In chil-

dren in particular, voluntary movements of the sound arm are sometimes accompanied by involuntary movements in the paralyzed arm, "associated movements."

Dependent upon the location of the lesion which has caused it, hemiplegia may be accompanied by other symptoms of great diagnostic importance. In right hemiplegia in right-handed people, in left hemiplegia in the left-handed, there is often speech defect through interference with the centers presiding over this function or with the fibers connecting them with one another. If the lesion is in the crus cerebri the third nerve on the same side may be involved so that there is paralysis of all the eye muscles except the superior oblique on the side of the lesion, with paralysis of the face, arm, and leg on the opposite side (Weber's syndrome), while if it is in the lower part of the pons the facial fibers will have already crossed and the seventh nerve being involved, the face is paralyzed on the same side as the lesion, the arm and leg on the opposite side. Both of these varieties are called alternating hemiplegia. In the latter, the upper facial muscles are involved. In a few cases there has been a lesion in the medulla about the region where the tongue fibers cross, so that while the face has escaped, the tongue is paralyzed on the side opposite the affected limbs. Lastly a lesion at the decussation of the pyramids may affect the arm on one side, the leg on the other—hemiplegia cruciata. In a certain number of cases of hemiplegia there is some loss of sensation on the affected side. This can come about in cortical lesions if the region behind the fissure of Rolando is injured, or from any lesion of the motor tract which is sufficiently extensive to involve at the same time the sensory tract which runs behind, the motor fibers in the capsule, in the tegmentum and in the pons. The different forms of sensation may be affected in different degree, but the loss is seldom complete and tends in time to be repaired, being permanent only when the fibers in the area behind the motor tract in the capsule (the "carrefour sensitif" of Charcot) are destroyed, or the optic thalamus is affected (Starr). In lesions of the parietal cortex, tactile sense is chiefly affected, so that the patient cannot recognize objects by their feel ("astereognosis"). Impairment of the muscular sense on the same side occasionally accompanies the paralysis (hemiataxia). Half-sided blindness (hemianopsia) may result if the lesion extends far enough backward to involve also the visual tract.

Vasomotor and trophic symptoms are an occasional accompaniment of hemiplegia, the most frequent manifestation being the bed sores which are seen in severe paralyses, though these are no doubt in part due to neglect. A muscular atrophy of cerebral origin has been described, while in a few instances an edema of the paralyzed limbs has been seen, the lesion in the latter condition having been very extensive, as in a case reported by the writer in 1898.

Since any disease of the brain which is sufficiently extensive to produce hemiplegia must disorder its functions more or less, there are few cases of hemiplegia in which there is not at least some slight mental impairment and in the more severe cases this may reach a degree in which memory, attention, judgment-forming capacity and emotional control, are so far damaged as permanently to prevent the victim from playing his part in the world.

Infantile Hemiplegia.—*Synonym:* Infantile cerebral palsy. A number of causes liable to act both before birth and within the first year or two of life may cause injury to the brain with arrest of development and hemiplegia as symptoms, and the picture in these cases differs enough from that seen in adult cases to warrant a few words of description.

Since these accidents occur before the development of the mental functions these are nearly always impaired and the child goes through life as a defective. (See Idiocy and Imbecility, under *Mental Deficiency.*) The paralyzed limbs fail to develop normally and remain smaller than those on the sound side, the rigidity and contractures are specially marked, and the deformity may be great. The reflexes are greatly exaggerated and athetoid and associated movements are common. Contrary to what is the case in infantile spinal paralysis the electrical reactions are normal and there is no muscular atrophy. Sensory and speech defects may accompany the paralysis, and epilepsy is common. The chief causes of early hemiplegia, after congenital defect of the brain, are hemorrhage, most frequent in cases born in difficult labor with prolonged pressure upon the head or instrumental delivery, embolism and thrombosis, and encephalitis or meningitis for which some acute infectious disease is usually the starting point. The conclusion has been forced upon us of recent years that the same infectious agent which, when it acts upon the spinal cord, produces a poliomyelitis, may, when it acts upon the brain, set up an encephalitis and so produce a paralysis of cerebral type.

Diagnosis.—Since hemiplegia is not a disease but rather a symptom, diagnosis concerns itself with determining the underlying cause. Since an hysterical paralysis may assume the form of hemiplegia, our first care must be to decide whether in a given case the trouble is of organic or of functional origin. To this end, the age of the patient and his (or her) general history, the circumstances which preceded and accompanied the onset of the paralysis, etc., must first be considered. In hysterical hemiplegia the face is rarely affected, the paralysis of the limbs is usually more complete than in organic paralysis, the patient seems incapable of making any use of them, the arm hangs like a flail and the leg is dragged after him in an entirely different manner from the swinging of organic hemiplegia. The reflexes are not exaggerated, there is no change in the electrical reactions and the affected side is often anesthetic, while some of the other stigmata of hysteria are frequently present. Neri has described the following sign which is of use in differentiating between organic and hysterical hemiplegia. "If a hemiplegic while standing, bends the body forward to a right angle with the thighs, the limb on the paralyzed side becomes flexed, while that on the sound side remains straight; and if when lying down, the legs are lifted up, the one on the paralyzed side becomes flexed when an angle of forty degrees is reached, while the sound leg can be lifted to at least sixty-five degrees without flexion." This does not occur in hysterical cases. From poliomyelitis with hemiplegic distribution of the paralysis, cerebral hemiplegia is to be distinguished by the fact that in it the paralysis is spastic not flaccid as in poliomyelitis, the reflexes are exaggerated, not lost, and the electrical reactions are unaltered, while in poliomyelitis there is apt to be partial or complete R D. The diagnosis of the position of a brain lesion causing hemiplegia has been sufficiently indicated under symptomatology, while that of the character of the lesion will depend upon the recognition or exclusion of the symptoms of the various morbid conditions which may cause the development of this symptom, such as cerebral hemorrhage, tumor, abscess, and syphilis, meningitis, encephalitis, etc.

Prognosis.—The prognosis of hemiplegia will depend upon the nature of the cause, whether removable or not, and upon the degree of the paralysis. If this is slight and the patient not too feeble there may be almost complete restitution. In severe hemiplegia which has lasted for a year or more, and especially if contractures have developed, there is little likelihood of further improvement. A patient who has had one stroke, especially if there is arterial disease with high blood pressure, is always in danger of another one, which may or may not prove fatal.

TREATMENT.—In the early stages the treatment is that of the apoplectic attack or of whatever other disease is responsible for the hemiplegia. After the paralysis is developed, there is little which can be done except to aid as much as possible the reparative efforts of nature in connection with whatever measures may suggest themselves as likely to prevent a renewed attack. Especially does the intelligent management of existing arterial disease impose itself as necessary.

As far as the paralysis is concerned, as soon as all symptoms of irritation have disappeared, massage of the limbs with passive movements should be begun and should be given twice a day. Electricity may be used to exercise the paralyzed muscles, but has no other value. As soon as any power begins to return, the patient should be encouraged to use it and any device which can assist him will be of value. It is to be remembered that while the pyramidal tracts carry the great bulk of the motor impulses, these can, in part at least, be relayed around by some of the other descending tracts, in case they are not involved in the lesion, so that it would seem possible that by a gradual reeducation they may be able to take on some of the functions of the damaged pyramidal tracts. Particular attention should be paid to the prevention of contractures as far as possible, by keeping the paralyzed limbs in suitable positions, by working them frequently, and by applying electricity in the form of galvanism to the extensors in the arm and to the flexors in the leg. It is claimed by some authors (Bing) that faradism should be avoided as it tends particularly to stimulate the muscles which produce the contracture.

When the patient has reacquired some power he may be encouraged to practice some of the movements favoring reeducation of the muscles as in the method of Fraenkel. In the hemiplegias of children, orthopedic measures may be required to correct the club foot and other deformities which occur, while in some cases which have been bedridden on account of the extreme spasticity and exaggeration of the reflexes in the affected muscles, cutting the posterior spinal nerve roots after the method of Foerster, has enabled the patient to get around with the aid of crutches or other apparatus.

Strict attention should be paid to improving the nutrition of the patient by means of full diet containing plenty of fat and such tonics as iron, quinine, and strychnine, cod liver oil, etc., should be administered. It has been an established practice to give iodide of potassium for long periods, on the theory that it hastened the absorption of clot or exudation. While much doubt has been thrown upon its action in this regard of recent years, experience seems to indicate that it has some effect upon existing arterial disease. In cases of syphilitic origin antisyphilitic treatment is, of course, indicated, not that it will cause regeneration of destroyed nerve tissue, but because it has a direct effect upon gummatous new formations and at least will tend to prevent fresh mischief.

CHARLES LEWIS ALLEN.

Hemiptera.—An order of insects that contains many species that trouble man. It includes the true bugs, of which the bed-bug, the "kissing-bug," and the assassin-bug are examples. See *Insects, parasitic.*

A. S. P.

Hemlock. See *Conium.*

Hemochromogen is probably the colored atomic group of hemoglobin and of its combination with gases, and this atomic group is united with proteins in the pigment. The characteristic absorption of light depends upon the presence of hemochromogen. It is this group which binds in the oxyhemoglobin one molecule of oxygen and in carbon-monoxide hemoglobin one molecule of carbon monoxide with one atom of iron. Hemochromogen may be formed in an alkaline solution of hematin by the action of reducing bodies. Hemochromogen in alkaline solution shows a beautiful cherry red color. It has two absorption bands, one between D and E, and the other between E and B.

F. P. U.

Hemocyanin. In certain of the Arachnidæ, Crustacea, Gastropodæ, and Cephalopodæ a substance analogous to hemoglobin has been found. This substance which contains copper has been designated hemocyanin. By the combination with oxygen this substance is transformed into blue oxyhemocyanin and by the escape of oxygen again becomes colorless.

F. P. U.

Hemoglobin which is also known as reduced hemoglobin or purple cruorin is found in small quantities in arterial blood, in larger amounts in venous blood, and after asphyxiation makes up nearly the entire pigment of the blood. Hemoglobin is very much more soluble than oxyhemoglobin and its crystals are therefore obtained with difficulty. A solution of hemoglobin shows a single absorption band between D and E toward the red end of the spectrum. A hemoglobin solution readily absorbs oxygen and is converted into oxyhemoglobin.

F. P. U.

Hemoglobinuria.—The excretion of hemoglobin in the urine, the red cells of the blood being absent or in insignificant numbers. The pigment excreted is usually in the form of methemoglobin. It imparts to the urine a color varying from a faint smokiness to red, brownish-red, or almost black, according to the quantity present. In intense hemoglobinuria, with the urine colored from deep port-wine to nearly black, if the urine be shaken a yellowish-pink froth is produced. When the hemoglobin is present in very small quantity it can be demonstrated by the turpentine-guaiac test. Whether oxyhemoglobin or methemoglobin is being excreted can be determined with the spectroscope, but is a matter of little or no clinical importance. The absence of red blood cells, at least in any considerable numbers, is determined by microscopic examination of the urine and is of great importance in making the differential diagnosis between hemoglobinuria and hematuria. In the latter condition, hematuria, the corpuscles may become disintegrated in a long-standing specimen, particularly if it has become ammoniacal. It is important therefore that urine as fresh as possible should be examined for diagnosis, to determine the presence or absence of corpuscles. Hematuria is a symptom usually of acute severe local injury to the urinary tract, from traumatism, calculus, ulceration, neoplasm, parasites, or irritant poisons. Hemoglobinuria is a symptom usually of a systemic disease, often of an infectious nature, causing hemolysis; it represents the excretion in the urine of hemoglobin already set free in the blood plasma. No diagnostic error, then, is more certain to lead to misdirected treatment than the mistaking of hemoglobinuria for hematuria, but this mistake has been made many times.

In hemoglobinuria the microscope will often discover a few red cells in the urine, but by no means enough to account for the amount of pigment present. Epithelium, urates, and amorphous detritus will probably be found in somewhat more than normal quantities. If large amounts of hemoglobin are being excreted in the convoluted tubules they fail to remain in solution in the secreted urine, but are deposited in Henle's loops and in the collecting tubules of the kidneys, forming plugs, *hemoglobin casts*, and blocking

the kidneys. Thus in an intense hemoglobinuria the urine will be diminished in volume from this cause. Hemoglobin is itself a diuretic, however, and except for this blocking of the tubules would tend to increase the flow. These facts should make it clear to the practitioner that no irritating or stimulating diuretic drug should ever be given in a case of hemoglobinuria, but diuresis should be promoted by efforts to increase water absorption by drinking, proctoclysis, and if necessary hypodermoclysis.

The urine is constantly albuminous in hematuria. It is also albuminous in hemoglobinuria but usually in a relatively moderate degree.

Hemoglobinuria not producing any discoloration of the urine macroscopically evident to the eye may be shown by the turpentine-guaiac test to exist in many cases; for instance, in such cases of subtertian malaria as show five per cent. or more of the corpuscles in a field to be infected with parasites. The turpentine-guaiac test is applied as follows: If the urine be not acid, make it so with a drop or two of acetic acid. Put an inch or two of urine in a chemically clean test-tube or small conical glass. Carefully stratify on top of it a mixture of equal parts of tincture of guaiac and oil of turpentine. If hemoglobin is present a cloudy ring gradually forms at the junction of the two layers and turns slowly to an intense blue. The tincture of guaiac used should be freshly or recently made and kept in an amber-colored bottle. It may be used in the full official strength, twenty per cent., or diluted with alcohol to a pale sherry color. The oil of turpentine employed must be ozonized, *i.e.* must be old. Fresh oil of turpentine can be ozonized by allowing it to stand for a few days in an open vessel in the sunlight.

Clinical Forms.—The principal clinical forms of hemoglobinuria, according to causes, are (1) toxihemoglobinuria, (2) paroxysmal hemoglobinuria, (3) hemoglobinuria of infants with congenital syphilis, (4) hemoglobinuria in Raynaud's disease, (5) infectious or epidemic hemoglobinuria of the new-born (Winckel's disease), and (6) malarial hemoglobinuria.

Toxic Hemoglobinuria.—This is produced by any hemolytic poison such as potassium chlorate in large doses, pyrogallic acid, carbolic acid, arseniureted hydrogen, carbon monoxide, naphthol, or muscarine. The toxins of some of the infectious diseases, as scarlet fever, typhoid, and malaria occasionally have the same effect. The red corpuscles having been destroyed by one of these poisons, their hemoglobin is left free in solution in the plasma; this condition, hemoglobinemia, being precedent to the hemoglobinuria. Quinine alone is not a cause of hemoglobinuria but in subtertian malarial infections the administration of quinine sometimes appears to act as a contributing or precipitating cause. Hemoglobinuria is sometimes seen after severe burns. A form of it, probably of a toxic nature, is seen in horses following exposure to cold and hard driving. Transfusion of blood from one animal to another causes hemolysis with hemoglobinuria. Experimentally, Oehler has produced hemoglobinuria in mice by causing them to drink only chemically pure distilled water.

Paroxysmal Hemoglobinuria.—This is a rare condition. It is seen oftenest in adult males. The attacks recur at irregular intervals, being especially liable to follow exposure to sudden chilling, even a cold foot bath in some cases invariably producing an attack. The attacks are usually of short duration, from a few hours to a day. They appear sometimes to be brought on by exertion or by bodily or mental exhaustion. Sometimes the hemoglobinuric symptom is accompanied by lumbar pain, vomiting, diarrhea, or pyrexia. Some perceptible degree of jaundice is usually present. The attacks are rarely, if ever, fatal.

In a recent study of paroxysmal hemoglobinuria (*Am. Jour. Med. Sci.*, August, 1912), Cooke says: "As a result of clinical observation, the Wassermann reaction, the luetin test, and the serologic studies in metasyphilitic disease, it seems safe to say that syphilis is the most important, possibly the only, etiologic factor in paroxysmal hemoglobinuria, but there are as yet no observations on the presence or absence of hemolysin after the disappearance of the Wassermann reaction as a result of syphilitic treatment."

Hemoglobinuria in Infants with Congenital Syphilis.—This is not to be confounded with the epidemic hemoglobinuria of the new-born. It is in all probability due to the presence in the infant's blood of a hemolytic amboceptor produced by syphilitic infection. If the connection of the paroxysmal hemoglobinuria of adults with syphilis be presently fully established, we shall be able to include it and the hemoglobinuria of syphilitic infants under one heading, *syphilitic hemoglobinuria.*

Hemoglobinuria in Raynaud's Disease.—The etiology of Raynaud's disease is at present undetermined. If further research shall show that it is to be placed among the metasyphilitic diseases, the hemoglobinuria incident to it will be ranged with those discussed under the two foregoing subheads, as a syphilitic hemoglobinuria.

Infectious or Epidemic Hemoglobinuria of the Newborn (Winckel's Disease).—This disease has occurred chiefly in lying-in and foundling hospitals in epidemics, but sporadic cases with the same symptoms have been seen in private practice. It was described first by Charrin of Paris in 1873 and more fully by Winckel of Dresden in 1879. It attacks infants in the first two weeks of life and, though nothing is known as to its etiology, it has all the ear-marks of an infectious disease. It is characterized by extreme cyanosis, icterus, hemoglobinuria, somnolence, rapid collapse, and death usually in from a few hours to two days. A few mild cases recover. Fever is slight or absent. The umbilical vessels show no signs of infection. Postmortem the spleen is found enlarged, hard, engorged with blood. The liver and heart sometimes exhibit an acute fatty degeneration. The blood changes and the condition of the kidneys are similar to those found in other forms of hemoglobinuria.

Malarial Hemoglobinuria. (See Blackwater Fever.)—This is the most severe, most serious, most frequently fatal of all forms of hemoglobinuria occurring in the adult. The chief dangers to be feared in this or any other form of hemoglobinuria of high degree are *kidney block* and *heart failure.* Quinine and diuretic drugs are absolutely contraindicated during any attack of hemoglobinuria. The treatment of malarial hemoglobinuria during the attack, as laid down in the article on *Blackwater Fever*, covers the general principles to be followed in treating a severe hemoglobinuria from any cause.

J. F. Leys.

Hemolymph Glands.—The hemolymph glands are lymphadenoid structures occupying a position intermediate between the spleen and ordinary lymphatic glands. In structure they closely resemble the latter, the essential difference between the two being that they possess blood sinuses in place of lymph sinuses. Transition forms between the two, however, exist; a gland may contain both lymph and blood sinuses; but the presence of the latter, however small, is sufficient warrant for its classification as a hemolymph gland. There are also transition forms between the hemolymph glands and spleen, many of the former, particularly in the lower animals, possessing a spleen-like pulp. The spleen itself may be regarded as a hemolymph gland; and undoubtedly many of the so-called accessory spleens fall into the class of hemolymph glands. The term hemolymph is not the most desirable designation for this type of blood organ;

but as it is the one first in use, it is most convenient to continue it. For those containing blood sinuses alone the term *hæmal* or *hæmolymphoid* node has been used, while those containing afferent and efferent lymphatics are given the designation hemolymph node.

Occurrence.—The existence of hemolymph glands was first noticed in the lower animals, particularly those used for food purposes. In the steer, pig, and sheep these structures are very numerous in the prevertebral fat, and conspicuous because of their deep blood color. From their number and size in these animals it is reasonable to suppose that their function is of importance. Butchers and meat dealers have long been acquainted with their gross appearances, but have usually regarded them as blood clots. From the scientific side they have been strangely neglected, though as early as 1857 Leydig pointed out the close resemblance between these glands and the spleen. More recently they have become objects of scientific investigation, and have been found to be present also in the goat, horse, dog, rat, guinea-pig, common fowl, and turkey. They vary greatly in number according to the species of the animal, and individual variation within a given species is also great.

Their presence in man has only lately become a matter of careful study, though lymph glands with blood-containing sinuses have been many times observed. Such findings were, however, interpreted as ordinary lymph glands into whose lymph sinuses there had been a hemorrhage or backward flow of blood. H. Gibbes, in 1884, was the first observer to consider such glands to be permanent and independent structures. A similar view was taken by Robertson in 1890, and to this observer we owe the designation hemolymph gland, this name having been suggested to him by Dr. Russell. The constant presence of these glands in the human body was confirmed later by Gibbes and Vincent, and were independently discovered more recently by the present writer. According to the investigations of the latter, lymph glands containing blood sinuses are found constantly in the human body, at all ages, and in both normal and pathological individuals. That these glands are organs *sui generis* and not hemorrhagic lymphatic glands is evident from the following facts:

First. Lymphoid nodes containing blood sinuses are constantly present in the human body in all conditions and at all ages.

Second. The structure of such glands differs in many respects from that of ordinary lymphatic glands; and the appearance presented by hemorrhagic lymphatic glands is wholly unlike that of a hemolymph gland. The direct communication of the blood sinuses with the blood-vessels can be demonstrated by injection.

Third. These glands in the human body show many points of similarity to the hemolymph glands found in the steer and sheep, and the latter from their number, size, constant occurrence, and individual structure must be regarded as organs *sui generis* without question. Nevertheless, a few writers continue to regard all *red lymphoid nodes* in man as altered ordinary glands or as temporary structures. Meek, in particular, regards them as lymph-nodes, that undergo modification as the result of circulatory changes. The writer has already pointed out that this is true with reference to a certain number of red lymph-nodes; but the constant presence of red nodes of a definite structure side by side with unchanged ordinary lymph nodes shows that circulatory conditions alone cannot account for these nodes with blood sinuses.

Fourth. The specific pathology of these nodes indicates a specific structure and function.

Location.—In the lower animals the hemolymph glands are found chiefly in the prevertebral fat, along the course of the aorta, renal and adrenal vessels, brim of the pelvis, and in the root of the mesentery. They rarely extend far out into the latter, but are occasionally found in the omentum and epiploica. They are also found associated with the peripheral and subcutaneous lymph-nodes, usually one hemolymph node to each lymphatic gland. They are also of less common occurrence in the mediastinal region. In man they are found in greatest numbers in the prevertebral, retroperitoneal, and cervical regions, in the neighborhood of the adrenal vessels, along the brim of the pelvis, in the root of the mesentery, but rarely extending far out into it, and are of very rare occurrence in the epiploica and omentum. They are also rare in the mediastinal tissues and along the thoracic aorta, except under conditions in which there is a general enlargement of all the hemolymph glands of the body, as in certain forms of anemia and leukemia. This fact suggests the possibility of new formation of these structures in these diseases or their existence as resting glands too small to be found under normal conditions.

Histology.—*Bullock.*—Hemolymph glands are found in the prevertebral fat of this animal to the number of several hundred. Their deep red color contrasted with the white fat in which they lie embedded makes them very conspicuous. They may be found associated with true lymphatic nodes in any part of the body, usually one hemolymph node lying in the hilum of the lymph gland. They are usually round with a slight indentation on one side; but vary from bean-shaped nodes to elongated masses. They vary in size from a pinpoint to that of a large cherry or almond. In many the blood sinuses occupy so large a part of the gland that they resemble blood clots. Their gross appearance varies greatly owing to the different proportions between the amount of lymphoid tissue and the size of the blood sinuses in different glands. On microscopical examination they show a great variation of structure in regard to the amount and arrangement of the lymphoid tissues and the number, size, and course of the blood sinuses. The capsule of the gland is usually very thin and contains yellow elastic tissue and unstriped muscle. The lymphoid tissue is often very scanty, consisting of small islands lying in the large blood sinuses, or, on the other hand, the greater part of the gland may be composed of lymphoid cells while the sinuses are small. In the large glands trabeculæ of connective tissue pass from the capsule toward the center of the gland. The sinuses are usually large and prominent, and in the majority of cases make up the greater part of the organ. They are both peripheral and central, with communicating branches, and are traversed by a coarse reticulum, which may be very scanty or so close and mesh-like as to give an appearance resembling spleen pulp. The reticulum is lined throughout with flattened endothelium. The lymphoid portion may show a division into cortical and medullary zones but often there is only a homogeneous mass of lymphoid tissue containing germinal centers, but showing no distinct division into cortical and medullary portions. Germinal centers may be present in the cortical portion, and in these numerous mitotic figures may be found. In the medullary portion the lymphoid tissue is usually arranged in columns between the blood sinuses. The cells of the lymphoid areas are chiefly lymphocytes, but large mononuclear cells, mononuclear eosinophiles, transitional and polynuclear form are numerous. Many of the cells of the reticulum and also of the endothelial cells lining the blood sinuses show a mast-cell granulation, but this varies greatly; sometimes the majority of the cells in the node are mast cells. In the central sinuses large mononuclear phagocytes are found in great numbers in the meshes of the reticulum, and these usually contain disintegrating red cells and blood pigment. The glands are supplied by numerous large arteries

which on entering the organ quickly break up into small vessels feeding the sinuses.

Sheep.—The hemolymph glands are as numerous and prominent in this animal as in the steer, and in structure closely resemble those found in that animal. They show the same general distribution as in the steer. They are not as large on the whole, and are more frequently round. As a rule, they contain more lymphoid tissue, and the sinuses are relatively smaller. Their capsule is also more delicate. The type with central lymphoid tissue and peripheral sinus is more common than in the ox. Phagocytes containing red cells and pigment are also less common, and the degree of hemolysis is evidently less. Giant cells resembling those of the bone marrow are not infrequently found in the reticulum. A very remarkable feature is the large number of mast cells present; in many glands nearly all of the cells in the central lymphoid area may show this granulation. Germinal centers are not so numerous as in the glands of the steer. Red blood cells are found throughout the reticulum of the lymphoid areas.

Horse.—The hemolymph glands of the horse have received but slight attention. They have been found chiefly in the neighborhood of the kidneys, no thorough study of the prevertebral region having been made. They appear as dark-red bodies of varying size and shape, the largest about 2.5 centimeters in diameter, the average diameter being about 1.5 centimeters. On section they resemble very closely the glands of the sheep; but usually contain a larger amount of lymphoid tissue which is grouped in regular nodes, each of which is surrounded by a well-defined blood sinus, usually of uniform width. Cells containing disintegrating red cells and blood pigment are numerous. In horses used for the production of diphtheria serum, large hyperplastic and deeply pigmented hemolymph nodes may be formed. Baum denies the existence of typical hemolymph nodes in the horse.

Goat.—Hemolymph glands similar to those in the steer and sheep are found in this animal, and in microscopical features they resemble those of the sheep, though less numerous and smaller than in that animal.

Pig.—The first observations of hemolymph glands were those made by Leydig in 1857, on the gross appearances of glands lying along the thoracic aorta in the pig, which bore a close resemblance to splenic tissue, and were regarded by him as intermediate structures between lymphatic glands and the spleen. Hemolymph glands are also mentioned by Clarkson as occurring in this animal, but no description of their microscopical appearance has ever been published.

Dog.—Hemolymph glands occur constantly in the prevertebral peritoneal fat, along the brim of the pelvis, and near the renal vessels. They may be of large size. In puppies they resemble closely those of the sheep; but in older dogs they are not very easily distinguished by the naked eye from ordinary lymphatic glands, in this respect being similar to those of the human body. They may often be recognized by a reddish peripheral zone or by red streaks corresponding to the blood sinuses. Phagocytes are numerous, and hemolysis may occur to a great degree as shown by the large amounts of blood pigment present. Under pathological conditions (splenectomy, ligature of splenic veins) there may occur a great new formation of hemolymph nodes in the mesentery and omentum of certain dogs, some animals under the same conditions showing nothing of the kind.

Rat.—Small oval or lenticular hemolymph glands can almost always be found at the lower border of the pancreas, near the kidneys, and in the gastrosplenic omentum. The sinuses are both peripheral and central; and are of large size. They are usually filled with red cells; but may be partly or wholly empty. Phygocytes are numerous, and the evidences of hemolysis are usually marked. The lymphoid tissue consists of both cortical and medullary zones, the former very dense but showing no germinal centers.

Guinea-pig. Hemolymph glands have been observed in this animal by workers in the writer's laboratory. They occur in the prevertebral tissues as minute points usually too small to be recognized by the naked eye. Their microscopical appearance is very similar to that of many of the hemolymph glands in man. The sinuses are small and are usually partly collapsed, the lymphoid areas are dense and only rarely show germinal centers. In many guinea-pigs it is impossible to demonstrate the presence of hemolymph nodes even with the greatest care.

Chicken.—Dark red glands resembling hemolymph glands to the naked eye have been found in the abdominal fat, near the stomach, and below the rectum. On microscopical examination the greater part of the gland is found to be composed of blood sinuses filled with nucleated red cells. There are numerous communicating branches between the central and peripheral sinuses. Pigment and phagoctyes containing red cells are abundant. Red cells are numerous throughout the reticulum of the lymphoid areas.

Turkey.—Glands similar to those in the chicken are found also in the turkey.

Fishes.—The head kidney of certain Teleostean fishes is analogous in structure to the hemolymph glands of the higher vertebrates, being composed of irregular masses of lymphoid tissue separated from each other by blood sinuses. The peripheral sinus is of large size.

Hemolymph glands have also been sought in the *monkey, rabbit, cat, squirrel, mouse, hedgehog, mole, pigeon, parrot, duck, frog, toad,* and many fishes without success. As these investigations were based almost wholly upon naked-eye appearances, it is highly probable that careful microscopical investigation of the tissues of these animals will show them to be present

Man.—Lymphoid structures containing sinuses filled with red blood cells are constantly present in the human body. To the naked eye they are not nearly so prominent as the glands of the sheep and steer because of the fact that their blood sinuses under ordinary conditions are more or less collapsed after death. Those possessing large sinuses are dark red in color; those with small or collapsed sinuses are recognized by their dark peripheral zone and red streaks corresponding to the blood sinuses. The search for these glands may be greatly facilitated by fixing the prevertebral tissues in four per cent. formalin, which bleaches other tissues, but darkens the blood-containing areas. In this way the blood sinuses are brought out very much more distinctly.

The human hemolymph glands vary greatly in location, number, and size, seldom occurring in exactly similar manner. They are larger and consequently more easily found in early adult life than in old age, becoming atrophic in late years. They are present in the newborn being particularly numerous in the posterior cervical and interscapular regions (so-called "hibernating gland" of Hatai). No difference has been observed in their occurrence in the sexes. They lie for the greater part deeply embedded in fat tissue, and possess a very rich vascular supply. The average size is that of a small pea, in shape round, bean-shaped or elongated in cord-like masses; their relative proportion to ordinary lymphatic glands is 1 to 20–1 to 50, but in some cases they are found in such large numbers as to suggest the possibility of new formation or of resting glands taking on an active state.

On microscopical examination the human hemolymph glands show an exceedingly great variation in structure. It would seem inadvisable to attempt to classify these variations, inasmuch as confusion would result from the numerous transition forms found. Broadly, two distinct types may, however, be distinguished, and to these I have applied the terms *splenolymph glands* and *marrow-lymph glands* as indicating their structure and probable function. It must be understood that there are no hard-and-fast

lines between these types, all possible transition forms existing between them, as also between them and ordinary lymphatic glands. My later investigations tend to show that the marrow-lymph type is most probably pathologic, the result of altered blood conditions.

The splenolymph gland is the more common form and is found chiefly in the neighborhood of the solar plexus, adrenal and renal vessels, brim of pelvis, and in the deep tissues of the cervical region, and occasionally in the mediastinal region, omentum, and mesentery. The glands are usually round but vary greatly in shape, often flat or cord-like, possessing a distinct hilum into which a large plexus of vessels passes. The capsule of connective tissue contains unstriped muscle and yellow elastic tissue. It may be very thick in proportion to the size of the gland, but not infrequently is very thin and delicate. From the capsule trabeculæ of varying size run into the organ cutting it up into irregular lobules; in small glands no distinct trabeculæ may be present. Immediately beneath the capsule there is a blood sinus of varying width which usually runs entirely around the periphery of the gland, but very often only for a portion of the way, being frequently interrupted by masses of lymphoid tissue reaching to the external capsule. Branches of the peripheral sinus run toward the center of the gland accompanying the trabeculæ. In the central portion they often become very large and prominent. The lumen of the sinuses is traversed by a coarse reticulum through the meshes of which the blood circulates. In the large central sinuses the reticular meshwork may at times be very scanty.

The reticulum of the sinus appears, in part at least, to be lined with endothelial cells, but these are with great difficulty made out, and in many places the blood seems to be in direct contact with the reticular surfaces. The circulation is therefore of the type described as sinusoidal. The nuclei of the cells of the reticulum stain much more lightly than those of the neighboring lymphoid tissue. There is apparently a direct continuation of the sinus reticulum with the reticulum of the lymphoid areas; and the latter may be regarded as the same structure enclosing in its meshes masses of lymphocytes. The number and size, as well as the general arrangement of the blood sinuses, vary greatly, so that scarcely any two glands resemble each other in these respects.

The lymphoid tissue lying between the blood sinuses resembles that of the spleen or ordinary lymphatic gland. It varies very much in amount, sometimes forming a mere network between the sinuses, while in other cases it may form the chief part of the gland. There is usually no division into cortical and medullary portions. Usually the greater mass of lymphoid tissue is toward the periphery, forming the inner border of the peripheral sinus; but frequently extending to the capsule, breaking up the peripheral sinus into small sections that run for a short distance only. Small round collections of lymphoid cells resembling splenic follicles are often seen. These occur more frequently at or near the periphery, but they may occasionally be found near the central portion of the gland. They may be partly or wholly surrounded by the blood sinus. The cells in the central portion of the follicle stain more lightly than those at its periphery. Serial sections show that these nodes are almost perfectly round in the majority of cases. Usually they possess no arterial relations, but occasionally a small capillary is found in them which under certain pathological conditions may become gradually converted into a small arteriole with thickened walls. The resemblance in this case to the splenic follicle is very complete.

The cells of the lymphoid area are for the greater part small lymphocytes. These vary greatly with respect to the relative size and staining power of the nucleus and the relative amount of protoplasm. Next to the small lymphocytes the large mononuclear leucocytes are the most common form present. These also vary much in size, form, and staining power. Transitional and polynuclear leucocytes are also present in varying numbers. A small number of basophile and mononuclear eosinophiles is also usually present; mast cells are rare in the majority of cases, but occasionally a gland may be found in which the majority of the cells of the central portion are mast cells, as is so frequently the case in the hemolymph glands of the steer and sheep.

The reticulum of the lymphoid areas resembles that of the blood sinuses, and is directly continuous with it. In its meshes lie the cells of the lymphoid tissue and also numerous red blood cells. The latter fact suggests the presence in the lymphoid tissue of very fine blood spaces similar to those in the spleen pulp, but differing from the latter in that the blood spaces are smaller and the reticulum is more dense. The reticulum of the large sinuses is much more abundant and of a coarser mesh than that of the lymph sinuses of the lymphatic glands. Small fibrillæ of elastic tissue and unstriped muscle may be scattered through it. In its meshes there are constantly present large mononuclear phagocytes containing disintegrating red cells and blood pigment. These cells are also found in the reticulum of the lymphoid tissue in connection with free pigment; but they are always more numerous in the reticulum of the medullary sinuses than elsewhere. Under normal conditions their number in individual glands varies greatly, the appearances suggesting a possible cyclical function of hemolysis. Glands containing many of these cells may be found side by side with others whose reticular spaces contain but few. The same appearances are found in the hemolymph glands of the lower animals, particularly in those of the dog and rat. Multinuclear giant cells, esinophile, basophile, and mast cells may at times be found in the reticular meshes. The phagocytes may arise either from leucocytes or from the endothelial cells lining the reticulum, chiefly from the latter.

Scattered masses and droplets of a fuchsinophile hyaline substance are often found throughout the lymphoid tissue; they are usually most numerous toward the periphery of the gland. They are frequently seen as highly refractile spherules lying in the meshes of the reticulum or enclosed in phagocytes. They are evidently the product of the destruction of red cells, as all stages of their formation can be found. In some cases the spherules are seen partly extruded from the phagocyte. They frequently give an iron reaction, especially those found in phagocytic cells.

Marrow-lymph Glands.—This type of hemolymph gland is of very much less frequent occurrence in the normal body; but is much more prominent in certain pathological conditions, suggesting the possibility of resting glands or new formations. In all probability this type is pathologic, representing the reaction of hemolymph nodes to altered blood conditions. In some cases they appear to arise directly out of adipose tissue. They have been found only in the retroperitoneal region, along the vertebræ and brim of pelvis, and always in close proximity to the large vessels, abdominal aorta, vena cava, common iliacs, adrenal and renal vessels. They are present most frequently behind the aorta or between it and the vena cava. These glands are usually flattened and elongated, their greatest dimension lying parallel to the axis of the neighboring vessel. They may possess a distinct hilum, but the number of vessels entering is not so great as in the case of the splenolymph gland. Lymph vessels are also found in connection with these glands. Not rarely the marrow-lymph gland is found as a slender cylinder several centimeters in

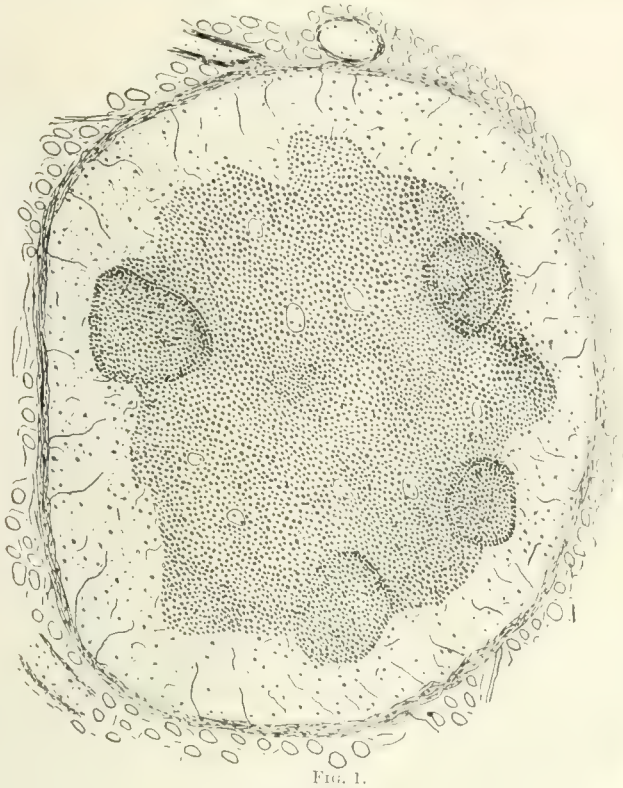

FIG. 1.

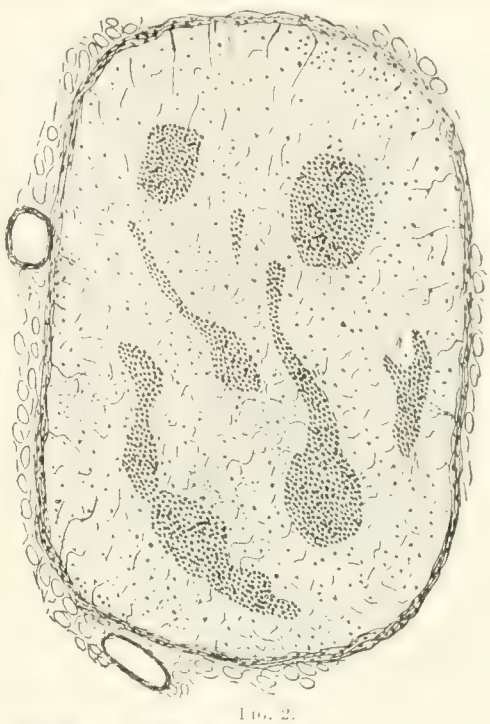

FIG. 2.

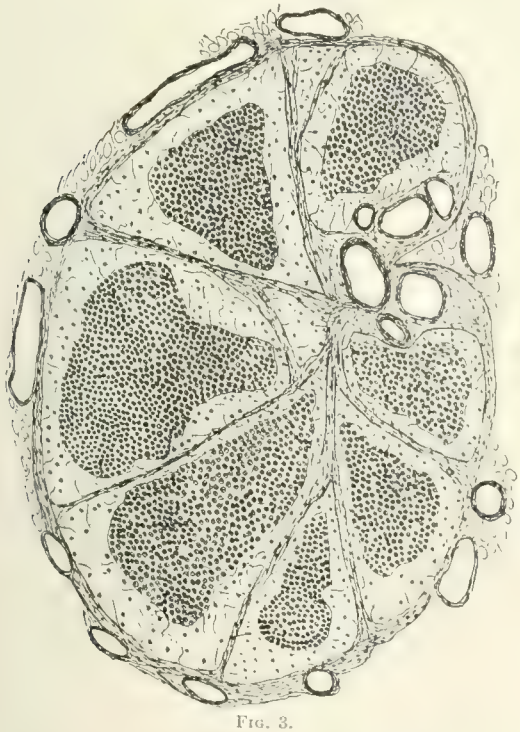

FIG. 3.

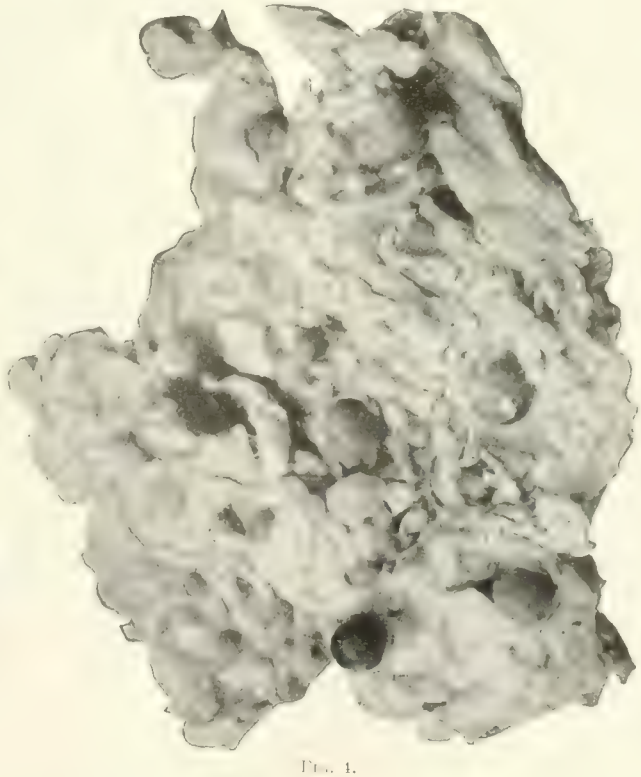

FIG. 4.

HEMOLYMPH GLANDS—(WARTHIN)

FIG. 1.—Common Type of Hemolymph Gland from Steer. Peripheral blood-sinus. Camera lucida drawing. Leitz objective 3, eyepiece No. II. Reduced one-third.

FIG. 2.—One of the Varieties of Hemolymph Gland from Sheep. The blood-sinuses form the greater part of the gland, the small irregular islands of lymphadenoid tissue are surrounded on all sides by blood-masses. Camera lucida drawing. Leitz objective 3, eyepiece No. II. Reduced one-third.

FIG. 3.—A Common Variety of Hemolymph Gland from the Human Retroperitoneal Region. Peripheral, centroacinar, and afferent sinuses, between which lie the masses of lymphadenoid tissue. Camera lucida drawing. Leitz objective 3, eyepiece No. II. Reduced one-third.

FIG. 4.—Hemolymph Nodes in Prevertebral Fat from Steer.

length embedded in fat. On section these glands are white or pinkish in color with fine red streaks corresponding to the course of the blood sinuses. Their consistence is very soft, and on section they present an almost homogeneous surface.

The capsule is thin and contains but little unstriped muscle and yellow elastic tissue. Delicate trabeculæ run from it toward the center of the gland. Beneath the capsule there is a peripheral blood sinus of small size which usually runs entirely around the gland, and from this there are narrow branching sinuses accompanying the trabeculæ toward the center of the gland. All of the sinuses are filled with a coarse reticulum through the meshes of which the blood circulates. Dilated sinuses as in the splenolymph glands are not present. The course of the sinuses is distinctly shown by the lighter staining nuclei of the reticulum and the presence of red cells. Lymph sinuses may also be present. Between the sinuses lies the lymphoid tissue arranged in irregular lobules. It is in much greater amount than in the case of the splenolymph glands. Throughout the lymphoid tissue, near the central portion of the gland, fat cells are present, either singly or in small groups. This may be regarded as one of the most striking characteristics of this type. Collections of cells resembling follicles are not present. The reticulum of the lymphoid areas is more delicate and scanty, and contains but little elastic tissue. The cells of the lymphoid areas present a much more striking variety of form and staining properties than in the splenolymph glands. Mononuclear eosinophiles and mast cells are more numerous; and multinuclear as well as large mononuclear forms with deeply staining knobbed nuclei may be present. Giant cells resembling those of the bone marrow are occasionally found, and in certain pathological states of the blood may be very numerous. No nucleated red cells have been found under normal conditions. Phagocytes containing red cells, pigment, fuchsinophile, hyaline bodies, and leucocytes occur to a less extent than in the splenolymph glands. Numerous red cells are found scattered throughout the reticulum of the lymphoid tissue suggesting the presence of smaller blood spaces.

Transition forms between spleno-lymph and marrow-lymph glands are found, and also between the latter and ordinary lymphatic glands. The various forms found are such as to suggest the idea that hemolymph glands are not permanent structures in any one form, but possibly show a certain amount of fluctuation. Thus the blood sinuses may become increased in size by a decrease of the lymphoid portion, while, on the other hand, an increase of lymphocytes may occur at the expense of the blood sinuses.

Circulation.—The exact mode of circulation in the hemolymph glands has not yet been worked out. It is probable that the arteries entering the hilum quickly divide into smaller branches which, passing toward the periphery, empty into the blood sinuses from which the blood is again gathered into veins which pass out at the hilum or obliquely through the capsule. The circulation in the sinuses is of the type known as sinusoidal, only the endothelium separating the blood from the cells in the reticular meshes. The current in these spaces must be very slow, and a long period of time must be required for the complete circulation through the intricate meshes of the reticulum crossing the sinuses. The relations of the lymphatic and blood systems in these glands are also unknown. It is possible that, in the human body at least, a mixture of blood and lymph, the so-called hemolymph, may be present in the sinuses, and that direct communication between the two systems occurs in some of these glands.

Development.—Little work has yet been done upon the development of these structures. They are found as fully developed organs in the new-born child, and have been found at an early period in the fetal calf. They are without doubt to be regarded as individual organs whose early stage of development runs parallel with those of the lymphatic glands. Their development is also parallel with that of the primitive fat-organs, as is beautifully shown in the posterior cervical and interscapular regions of the human fetus. The collection of hemolymph nodes in the posterior cervical and interscapular regions interpreted by Hatai as representing the hibernating gland of lower animals is nothing but a group of primitive fat organs and developing hæmolymph and lymphatic nodes. Such formations occur in the deep cervical tissues anteriorly, the mediastinum and near the kidneys and adrenals. Under certain pathological conditions it is possible that hemolymph nodes are developed from ordinary lymphatic glands or from adipose tissue in compensation for the spleen or bone marrow.

Function.—The hemolymph glands are so numerous in the steer and sheep that their function is obviously of importance. In other animals and in man, while constantly present, they do not under ordinary circumstances attract attention through either their numbers or their size. The constant presence of phagocytes containing disintegrating red cells and pigment would indicate that extensive hemolysis is one function carried on in these structures. As before mentioned, the presence of glands containing many phagocytes in their sinuses side by side with those whose sinuses contain only red cells would indicate a cyclical function; and there are many other appearances to suggest this. Under normal conditions no evidence of the formation of red cells has been observed, unless the occasional presence of bone-marrow giant cells may be taken as an indication of this process. The presence of these in the sinuses may, however, be explained on the assumption of giant-cell embolism. Under pathological conditions, such as anemia and leukemia, the hemolymph glands, particularly those described as marrow glands, show evidences of increased functional activity in the hyperplasia of all the glandular elements and the increased number of mitoses in the lymphoid cells. In addition large numbers of giant cells may be found in the reticulum of the sinuses and in the lymphoid areas, evidently formed in the gland; also nucleated red cells, myelocytes, etc., may be present, so that the gland may come to resemble lymphoid marrow. These changes are not shared by the other lymph glands of the body. The hemolymph glands are also to be regarded as important centers of leucocyte formation. After splenectomy or in certain pathological conditions of the spleen the splenolymph glands may compensate for this organ through hyperplasia and increased hemolytic activity. In short, the hemolymph glands normally possess a hemolytic function and give rise to leucocytes; under pathological conditions they may also become centers of red-cell formation. That they possess some part in the protective functions of the body is shown by their extraordinary hyperplasia in Texas and East African fevers in cattle, and in sleeping sickness in man. Hyperplasia of the hemolymph nodes is particularly characteristic of chronic protozoal infection, as shown by the writer.

Pathology.—The more common pathological processes, such as congestion, inflammation, tuberculosis, metastases of malignant tumors, etc., have been found affecting these glands in common with the ordinary lymphatic glands. In a limited group of conditions such striking changes occur that they must be regarded as specific in character. These changes are confined entirely to cases showing more or less marked pathological alterations of the blood. Very few pathologists or anatomists appear to recog-

nize the presence of hemolymph nodes. In the ordinary autopsy they usually are not seen at all; and unless the prosector has made himself familiar with them he is likely to miss them entirely. The pathology of these organs is almost wholly the work of the writer, who has given nearly twenty years to the study of these organs.

Anemia.—In all of the cases of anemia examined either the splenolymph or the marrow-lymph glands showed changes of greater or lesser extent, varying with the nature and degree of the anemia.

Post-hemorrhagic Anemia.—In a case of fatal anemia following repeated and prolonged attacks of epistaxis the only lymph glands showing change were those of the retroperitoneal region, particularly those in the neighborhood of the solar plexus. These were moderately enlarged, of a pink color and soft consistence. On microscopical examination they presented a structure resembling in the most striking way the lymphoid marrow. Throughout the reticulum of the sinuses and lymphoid areas were numerous giant cells in all respects resembling those of the marrow. The findings admitted of but one interpretation: these giant cells must have been formed within the gland, most probably from the reticulum or the endothelium lining it. Large numbers of mononuclear eosinophiles, nucleated red cells of large and small size, large mononuclear leucocytes corresponding to myelocytes, and all possible varieties of transitional forms were also present. The bone marrow of this case showed scattered areas of lymphoid marrow, and in both the liver and spleen changes were found suggesting a return to a fetal mode of blood formation. Numerous nucleated red cells were present in the blood. The remaining lymph glands showed only a fibroid hyperplasia.

Secondary Cachectic Anemia.—In a large number of cases of cachectic anemia both marrow- and splenolymph glands showed increased hemolysis, but no evidences of the formation of red blood cells were present.

Splenic Anemia.—In a case of splenomegaly with severe anemia, the patient dying after splenectomy, numerous minute nodes of lymphoid tissue were found scattered throughout the adipose tissue of the mesentery and retroperitoneal region. The majority of these possessed a small arteriole showing a much thickened wall; in some cases the lumen was completely obliterated by the proliferation of the intima. The new tissue blocking the vessel in many cases showed a hyaline change, and the concentric arrangement in some instances bore a strong resemblance to the thymus corpuscle. In some cases the hyaline tissue had undergone calcification. This new formation of lymphoid tissue resembles very much the changes found in the omentum of animals whose spleens had been experimentally removed, and is probably to be interpreted as compensation for the diseased spleen. The splenolymph glands in this case showed also such changes that they resembled splenic tissue, both to the naked eye and on microscopical examination, being regarded at the autopsy as accessory spleens.

Pernicious Anemia.—In numerous cases of pernicious anemia examined the changes in the hemolymph glands were so constant and so marked that the writer regarded them as specific in nature. Since his original report upon this subject he has repeatedly confirmed this finding in cases of pernicious anemia of the hemolytic type. In the more rapidly progressing forms the number of splenolymph glands is so great that they must be regarded either as new formations or as resting glands become active. In one case over sixty of these glands were removed from the cervical, thoracic, and retroperitoneal regions; and in another over thirty from the retroperitoneal region alone. The glands are enlarged and darker in color, often a chocolate brown. On microscopical examination the central and communicating sinuses are found almost filled with large phagocytes containing red cells and pigment. The processes of hemolysis are increased to an extraordinary degree, particularly in the rapidly progressing forms. The spleens in these cases showed but little evidences of hemolysis, while liver and kidneys showed marked hemosiderosis. In all of the cases there was marked atrophy of the red marrow associated with osteoporosis and the formation of cystoid cavities filled with liquid fat.

In one case of progressive anemia extending over three years, characterized by repeated severe attacks of epistaxis, hematemesis, and bloody stools, the only pathological changes of importance found on autopsy were in the retroperitoneal lymph glands. These were enormously enlarged, forming an almost continuous double row on each side of the abdominal aorta and diverging below along the brim of the pelvis. Each gland was three to four centimeters in length and one to two centimeters in thickness. They were almost cylindrical, somewhat flattened, and were dark red in color, almost black. On section the blood flowed freely from the greatly dilated sinuses. On microscopical examination a great hyperplasia of the lymphoid tissue was found, extending beyond the original capsule of the gland into the surrounding fat tissue. The appearances suggested strongly the possibility of a direct conversion of fat into lymphoid tissue. The presence of blood sinuses proved these glands to be hemolymph glands of the marrow-lymph type, and the process was interpreted as a compensatory hyperplasia for the bone marrow which was atrophic and cystoid.

Aplastic Anemia.—In cases of aplastic anemia with bone-marow exhaustion, as in severe bacteriemia (acute miliary tuberculosis, streptococcemia, etc.), the hemolymph nodes may show myeloid changes.

Leukemia.—In a case of mixed leukemia an enormous hyperplasia of the marrow-lymph glands similar to the above was found. On microscopical examination the blood sinuses were found filled with giant cells which were also scattered throughout the lymphoid areas. Mononuclear eosinophile cells, nucleated red cells, myelocytes, and an almost infinite variety of leucocytes, especially well shown in specimens stained with the tri-acid stain, made up the lymphoid portions. The resemblance to lymphoid marrow was very close, as in the case of fatal anemia following epistaxis. The other lymph glands showed but slight enlargement due to the increased number of leucocytes present. The bone marrow showed but little lymphoid increase; the spleen was greatly enlarged. The changes in the marrow-lymph glands are to be interpreted in this case also as being evidence of the ability on the part of these glands to take up the blood-forming function of the bone marrow.

Chloroma.—In this form of leukemia the prevertebral hemolymph nodes show chloromatous changes before the ordinary lymphatic.

Hodgkin's Disease.—Myeloid changes occur in the hemolymph nodes in a certain number of cases of this affection. The changes characteristic of the disease may be more marked in the spleen and hemolymph nodes than in ordinary lymphatic glands.

Leucocytosis.—In cases of pyemia showing marked leucocyte increase the hemolymph glands exhibit evidences of increased activity in the cells of the lymphoid areas, as shown by numerous mitoses. The mononuclear eosinophiles are also increased in number and nucleated red cells and giant cells may also be found.

Pseudomelanosis.—The hemolymph nodes may be found *black* at autopsy while the ordinary lymph nodes are unaffected, as in three cases reported by the writer. The change is due to the action of H_2S upon the blood pigment contained in the nodes.

Acromegaly.—In one case seen by the writer the deep cervical tissues showed hyperplastic hemolymph nodes.

Adiposis Dolorosa.—New formation of hemolymph nodes has been observed in the subcutaneous fat.

Chronic Protozoal Infections.—Texas fever, East Coast fever, and sleeping sickness are characterized by a marked hyperplasia of these nodes. The hyperplasia may be *lymphoid, endothelial, myeloid,* or *fibroid.*

Experimental Pathology.—In animals whose spleens have been removed the hemolymph glands may show hyperplasia and evidences of increased hemolysis. Ligation of the splenic vein will be followed after a year by an extraordinary new formation of hemolymph nodes throughout the mesentery and omentum in individual dogs. In poisoning with hemolytic agents such as pyrogallic acid, muscarine, toluylenediamine, etc., these glands show greatly increased hemolysis, the sinuses being packed with phagocytes containing red cells and pigment.

Summary.—By the above cases it is shown that under pathological conditions of either the spleen or bone marrow, the hemolymph glands may assume either a hemolytic or a hematopoietic function; and that in all conditions characterized by increased hemolysis the chief seat of the blood destruction or elaboration of blood-products appears to be located in the sinuses of these organs. In chronic protozoal infections a marked hyperplasia of hemolymph nodes takes place indicating some specific reaction to the infection. Aldred Scott Warthin.

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Hemolysis.—*Synonyms:* Hemocytolysis; Hematolysis; Laking of blood; Globulysis; Erythrocytolysis.

Although etymologically this term includes destruction or solution of both red and white corpuscles, yet by usage it has come to be applied, when used without specification, only to the erythrocytes. When corresponding changes of the leucocytes are considered, the specific term *leucolysis* or *leucocytolysis* is generally used. In this article the term hemolysis will be used, as above indicated, to apply only to *erythrocytolysis.*

In hemolysis the essential phenomenon consists in the escape of the hemoglobin from the stroma of the corpuscles into the surrounding fluid. As it is not exactly known in what way the stroma holds the hemoglobin normally, whether purely physically or in part chemically, or whether the stroma consists of a spongioplasm or a sac-like membrane, or both, the ultimate processes that permit the escape of the hemoglobin are not finally solved. However, the agents by which the escape is brought about are well known and extensively studied, and they are found to be of extremely various natures. They may be roughly classified as: (1) Known physical and chemical agents; (2) unknown constituents of blood serum; (3) bacterial products; (4) certain vegetable poisons; (5) snake venoms.

While the known chemical and physical agencies in the production of hemolysis have much significance in physiology, and to some extent in pathology, yet the importance of the subject of hemolysis rests chiefly upon the work now being done with blood serums; and in turn the chief importance of this work lies in its relation to problems of bacterial destruction, cell destruction, and the general laws of cell susceptibility and cell resistance. Hence we shall devote particular attention to the subject of serum hemolysis, appreciating that whether time does or does not show this work to be of as far-reaching importance as is now hoped, yet in any event it will mark a distinct period in the history of medical science. As being by far the simpler, however, we shall first discuss:

(1) Hemolysis by Known Chemical and Physical Agencies.—If distilled water is added to corpuscles of any kind, osmotic changes are bound to occur, since within the cells are abundant salts, soluble in water, which will begin to diffuse outward in an attempt to establish osmotic equilibrium between the corpuscles and the surrounding fluid. Conversely water enters the corpuscles at the same time, and accumulating there leads to swelling until such injury has been produced as permits the hemoglobin to escape and enter the surrounding fluid. Before this occurred the fluid was opaque because of the obstruction to light offered by the red cells. The stroma now settles to the bottom, while the hemoglobin diffuses into the fluid, making it red, but perfectly transparent. This process has long been known as the "laking" of blood, and is essentially the condition present in all forms of hemolysis. That the hemoglobin escapes only through injury of the stroma and not through simple osmotic diffusion is shown by the fact that if salt solution of the same concentration as normal serum is used instead of distilled water, no such escape of hemoglobin occurs. As hemoglobin is perfectly soluble in the salt solution it should pass out if it diffused as do the salts. Since there is no escape of hemoglobin in such a salt solution, it is evident either that the stroma is not permeable to hemoglobin, or else the hemoglobin is in some way attached to or combined with the stroma. Again, if the corpuscles are placed in a solution of salt more concentrated than their own fluids, water escapes and the corpuscles shrink; as no hemoglobin escapes with the water it is evident that the stroma is not permeable to hemoglobin when intact. Therefore it would seem that hemolysis by distilled water may be purely physical, produced by the cell stretching until rupture occurs and the hemoglobin escapes as from a sac, or else it may be that the stroma is partly soluble in water but not in salt solution, so that the distilled water dissolves the stroma and the hemoglobin escapes from its attachment. Because of the resemblance of the process of hemolysis to the rupture of plant cells with escape of their contents when they are placed in distilled water, it might be assumed that hemolysis is largely a physical matter, but there are many indications that chemical changes must be involved. For example, if a red corpuscle in an isotonic solution is cut into pieces the hemoglobin does not escape, indicating that its structure is quite dissimilar to that of the simple vegetable cell, and that there is some union of stroma and of hemoglobin other than physical.

Repeated alternate freezing and thawing is another physical means of bringing on hemolysis. Heating to 62° to 64° C. causes hemolysis of mammalian corpuscles; in cold-blooded animals this seems to occur at a slightly lower temperature.

Some chemical agents, as might be expected, are capable of liberating hemoglobin, even when the corpuscles are in isotonic solutions. The ordinary salts of serum, of course, do not have this property, but ammonium salts are strongly hemolytic. Urea also will dissolve red corpuscles. The chemical agents that dissolve red corpuscles seem to be those that have the power of penetrating the stroma. Ammonium salts and urea penetrate the corpuscles freely and cause hemolysis. Sugar and NaCl seem not to penetrate the corpuscle, and therefore do not produce hemolysis. Of the permeating substances there seem to be two types: One, like urea, does not produce hemolysis when in a solution of NaCl isotonic with the serum; the other, like ammonium chloride, is not prevented from producing hemolysis by the presence of NaCl. All these agents seem to effect hemolysis by acting on the stroma, for when the stroma of corpuscles hardened in formalin has its lecithin and cholesterol removed with ether, saponin, a powerful hemolytic substance, seems to have no effect. The action of saponin and of many other hemolytic agents can be prevented by the presence of cholesterol in excess, suggesting that it is this constituent of the stroma that is affected. The fact that chloroform, ether, and amyl alcohol will cause laking is probably intimately connected with the fact that lecithin and cholesterol, important constituents of the stroma, are both soluble in these substances. Nearly all these non-specific hemolytic agents are more or less inhibited by serum, in which action probably both the protein and cholesterol take part. Arseniureted hydrogen when inhaled causes intravascular hemolysis, and there are many other drugs and chemicals with the same property, among which may be mentioned nitrobenzol, nitroglycerin, and the nitrites, guaiacol, pyrogallol, acetanilid, and numerous aniline compounds. Alcoholic extracts of tissues are commonly hemolytic, the active constituent probably being soaps, which increase in hemolytic power in proportion to the degree of unsaturation of their fatty acids. The bile acids and their salts will also produce hemolysis, as seen in jaundice. Sodium bicarbonate solutions of one or two per cent. are hemolytic for some varieties of corpuscles, but 0.1 per cent. Na_2CO_3 and $NaHCO_3$ do not cause hemolysis. On the other hand, AsH_3 which causes severe hemolysis in the living animal does not have any hemolytic effect *in vitro*. This same difference is exhibited by some other poisons, and the hemolysis with these substances is probably secondary to the tissue injuries which they produce; from the injured tissues hemolytic substances are produced.

Leucocytes are dissolved by some of these agents, particularly the bile salts, although they are affected by no means so rapidly or so much as are the erythrocytes. There seems to be no relation between the erythrolytic and leucolytic powers of these substances. Water causes swelling, with solution of the granules in time, and the same is true of ammonium-chloride solutions. Bacterial poisons, especially those from pyocyaneus and diphtheria bacilli, have marked leucocytolytic effects.

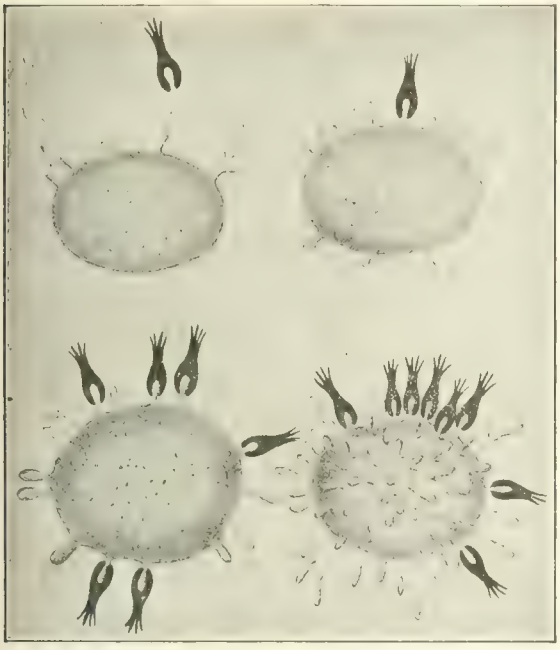
(2) Hemolysis by Serums.—With these facts as to the physical and chemical properties of the red corpuscles, we may consider the features of serum hemolysis. Since a very early time it has been known that it is not possible to substitute the blood of animals for the blood of man by transfusion, because the corpuscles of both transfused and native blood soon suffer destruction. Animal experiments also showed that as a general rule the blood of one animal cannot be substituted for that of another of a different species. This observation was not extended, however, until attention was drawn to it later by experimental investigations that may be said to have begun with the observations of Belfanti and Carbone. They found that if the red corpuscles of a rabbit were injected into a horse repeatedly, the serum of the horse became very toxic for rabbits, because it caused dissolution of their red corpuscles. It also developed that this same hemolytic property was manifested when the serum was added to rabbit corpuscles in a test-tube. When Bordet showed the similarity of this process with the solution of bacteria by serum, a process that had already been studied in a similar manner, the phenomenon of hemolysis by serum suddenly leaped into importance, and has now for some time occupied the attention of a large part of the bacteriological and pathological laboratories of the world. In hemolytic experiments we have a means of studying the property of blood serum of destroying cells under varying conditions, which is extremely easy to observe and control as compared with the less readily examined bacteria or tissue cells. Whatever the future may develop as to their ultimate worth, there can be no doubt that hemolysis experiments have given us many new and clear conceptions of the means of defense of the body against bacteria, and also of changes in cells of other sorts, that would not have been secured by any other method, to say nothing of so valuable a diagnostic procedure as the Wassermann reaction.

The manner of conducting hemolysis experiments is usually about as follows: Blood corpuscles of the kind to be tested are secured by defibrinating the freshly drawn blood in the usual way, by whipping. A five-per-cent. solution of these corpuscles is made by adding nineteen parts of 0.75 per-cent. NaCl solution, which is isotonic with them. This emulsion is placed in test-tubes, very small ones by choice in order to save material, and the serum that is to be studied is added to it. It is necessary that the tubes be cleaned as for chemical research and sterilized, and all steps of the experiments should be under aseptic precautions to prevent bacterial action affecting the experiments. As Jordan has shown that even the degree of alkalinity possessed by some varieties of glassware when new may cause hemolysis, the tubes should be cleaned with the usual acid cleaning fluid. The tubes, stoppered with cotton, are kept at 37° C., and in the course of from fifteen minutes to two hours the hemolysis will be manifested by the diffusion of the hemoglobin upward into the supernatant fluid, while the turbidity produced by the red corpuscles disappears. At the bottom of the test-tube the stroma collects as a slight sediment.

The Mechanism of Hemolysis.—If a serum from an animal immunized against the red corpuscles of another animal is allowed to act upon such red corpuscles in a test-tube, hemolysis occurs promptly. Bordet showed that this property was lost if the serum was heated half an hour at 55° C., indicating that the destroying agent was very sensitive to heat. In addition he found that if to such heated serum, deprived of all hemolytic power, there was added a small amount of serum from an animal that had not been immunized and which was of itself inert, the combination was quite as active as the unheated immune serum. In other words, there is contained in normal serum a substance easily destroyed by heat, that needs to be present to cause such specific hemolysis. But this *thermolabile* substance alone is not able to dissolve the red corpuscles, as the normal serum is found to be quite inactive; it is necessary also to have present some second substance that appears in the serum during the process of immunization. And as heated serum is also quite inactive it is apparent that this heat-resisting (*thermostable*) substance is not of itself able to dissolve the corpuscles. Therefore evidently two substances are needed to dissolve the corpuscles: one, which is easily destroyed by heat and which is present in normal serum; the other, which is present in sera of immunized animals, and which resists heat. Before Bordet had demonstrated these facts about the red corpuscles he had found out that the same condi-

tions prevailed in the destruction of cholera spirilla by the serum of animals immunized against them—two similarly behaving bodies are required in the solution of the organisms, the so-called "Pfeiffer's reaction." Out of these fundamental observations have grown

chemical laws the substance that has the greatest affinity will attract the toxin until it is saturated, and only on condition that there are other substances with the same degree of affinity for the toxin. By ordinary



Figs. 3121 and 3122.—Ehrlich's Diagrams Illustrating the Mechanism of Immunity and Cytolysis. 1, 2, and 3 illustrate different forms of receptors, showing the necessity for agreement of the combining bodies. The figures in black indicate substances with toxic action. 4, 5, and 6 illustrate the excessive production of receptors in response to the action of toxins, and their escape from the cell; in 6 they are seen to combine with toxin outside the cell, preventing its union with the cell; 7 shows the structure of the complement and intermediary body of bacteriolytic and cytolytic sera; 8 shows the amboceptor, while attached to the cell, uniting the complement to a large molecule.

the vast amount of research on serums in their relation to immunity, and on them have been based the theory of Ehrlich as to the ultimate nature of the processes of bacterial and cellular destruction that protect the body from infection and disease, and which perhaps play a part even in normal metabolism.

Ehrlich's Theory of Hemolytic Processes.—Although Ehrlich's ideas stand only as theories, and nothing more, still the fact that they have given us some sort of mental image upon which to base investigations of undoubted value, places them in a certain position of permanence. For this reason we shall endeavor to set them forth briefly in this article.

The Nature of Toxin and Antitoxin.—The fundamental feature of Ehrlich's theory rests upon a conception of the manner in which a toxin attacks a cell. If we consider a cell purely as a mass of various chemicals, and a toxic material as another chemical substance, either simple or complex, it will be apparent that the toxic substance will affect the cell if there is a chemical affinity between them. If there is no such affinity that particular toxic substance is not harmful for that particular cell. On the other hand, if the toxic substance and the cell do possess a chemical affinity they will unite, and the composition of the cell will be altered. When the uniting substance is toxic the result of the union is an injury of some kind to the cell. Undoubtedly other substances may unite with the cell without injuring it, for example, food supplies.

If this line of reasoning be carried still further, it will be readily seen that of the many substances of different chemical nature that compose a cell, not all can have affinity of varying degrees will more than the one susceptible substance unite with the toxin. We can thus conceive of a cell with one or more constituents that may become united to any given toxin with varying readiness. To these cell components that combine with the toxin the name *receptor* has been given by Ehrlich, and is generally applied. It will be readily seen that if a cell is affected by a toxin that fact implies the presence in the cell of a receptor for the toxin. Conversely an absence of proper receptors will explain the lack of susceptibility of certain other cells to the same toxin. For example, we may consider that some animals are immune to tetanus because the cells of their nervous systems contain no receptors that will combine with the tetanus toxin. To make the analogy to chemical reactions, Ehrlich has likened the receptors to the various *side chains* of organic compounds.

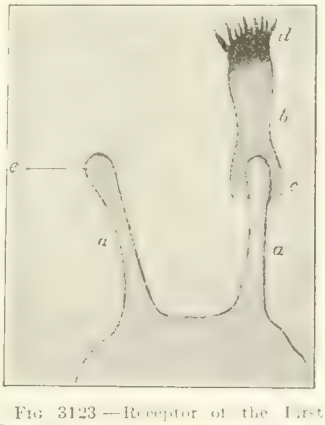


Fig. 3123.—Receptor of the First Order (*a*). *c*, Haptophore complex. *b*, combined toxin molecule, with haptophore (*c*) and toxophore (*d*) groups. (After Ehrlich.)

Figs. 3121 to 3125 represent in diagrammatic form the principles involved, in which definite forms are made to indicate chemical groups, and differences in their configuration to indicate differences in chemical affinity. The protrusions from the cells indicate the receptors or "side chains" that combine with outside substances. Each particular variety of receptor combines with the particular toxin for which it has a chemical affinity, as indicated by correspondence of configuration. In these diagrams toxic bodies are

FIG. 3124.—Receptor of the Second Order (ag_1l) with haptophore (a) and zymophore (g) groups. f, combined food molecule. (After Ehrlich.)

always indicated in black; and the black objects represent toxins which combine with the particular receptors they fit, or, in other words, for which they have a chemical affinity.

The body known as antitoxin is evidently one that has the power of combining with the toxin, for it has been demonstrated repeatedly that mixtures of toxin and antitoxin in proper proportion that have stood together a short time are quite inert; the union seems to be after the nature of the union of chemicals. This fact likens antitoxin to the receptors which have just been described, and in fact it is considered that antitoxin and receptor are identical substances, with the difference that the receptor is a part of a cell, while the antitoxin exists free in the serum. Ehrlich's explanation of the formation of antitoxin is as follows: When the toxin combines with the receptors of a cell, the cell is deprived of these receptors for whatever use they may have under normal conditions. Obeying the laws of regeneration the cell replaces these lost groups by new ones; indeed it replaces them in excess, much as in the healing of a wound there is an excessive formation of new cells. The excessive receptor bodies fall away from the cell into the serum, where, if they meet with any toxin, they will combine with it just as well as if they were still attached to the cell. Of course if the toxin is saturated with receptors while in the serum, it is devoid of any affinity for the receptors attached to the cells and does not harm the cells. In this way the cells are protected from the toxin. So, when we inject diphtheria antitoxin into the body of a patient, we are merely introducing receptors from the susceptible cells of a horse. These meet with the molecules of diphtheria toxin while it is still in the blood, and combining with it there prevent it attaching itself to any of the cells of the patient, and so it is rendered incapable of causing harm. The diphtheria antitoxin is not only able to combine with diphtheria toxin which is in the circulation, but if in excess to wrest from the cells toxin which may have already been combined, probably by the law of mass action. This always happens when a case of diphtheria is cured by antitoxin, and the clinical evidence of the "wresting" process is the sudden subsidence of the disease. It is not so easy to wrest tetanus toxin from the nervous tissue with antitoxin, and accordingly tetanus is not often cured by antitoxin given after characteristic evidences of alterations in the central nervous system have appeared.

One of the strongest proofs of Ehrlich's conception of antitoxin and toxin is that furnished by Wassermann's experiment. This consists in permitting tetanus toxin to stand for some time in contact with nervous tissue; it will then be found that the fluid part has lost all of its toxic property, and further, that the cellular portion which presumably contains the toxin is also not toxic. This agrees fully with Ehrlich's idea that a toxin attacks the cells that have receptors for it, and when so combined is harmless for other cells. In this case the nerve cells have combined with the toxin just as does antitoxin and have rendered it unable to attack other nerve cells. Other tissues are found to be quite unable to fix tetanus toxin in this way. A similar action has been found by Flexner to exist between nervous tissue and the specific nervous poison of cobra venom. The union of toxin and antitoxin seems to be of strictly chemical nature, for it follows the usual laws of chemical union, and it seems impossible to separate again the toxin and antitoxin after they have combined.

No. 4, of Fig. 3121, and No. 5, of Fig. 3122, illustrate the overproduction of receptor groups, which are liberated and enter the blood plasma. No. 6 (Fig. 3122) indicates the combining of the receptors with the toxin molecules, and shows how incapable they now are of combining with the cell.

In the process of immunization, under this conception, the receptors of the cells are repeatedly combined with toxin, and the resulting reaction on the part of the cells causes the discharge of large numbers of free cell receptors into the blood. These receptors give the serum whatever antitoxic property it may have.

The Structure of Toxins.—We have referred to the fundamental conception of a toxic substance as a substance which by combining with the receptor of a cell injures the cell in some way. It has been developed that toxin accomplishes this injury by a portion of itself that is different from the portion that combines with the receptor. In other words, a toxin

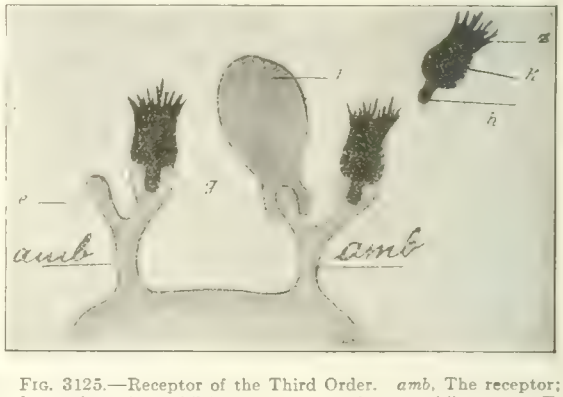


FIG. 3125.—Receptor of the Third Order. *amb*, The receptor; *e*, haptophore (cytophile) group; *g*, complementophile group; *K*, complement, with haptophore (*h*) and zymotoxic (*z*) groups; *f*, combined food molecule. (After Ehrlich.)

consists of a substance that binds it to the cell, and of another that causes the injury to the cell. This may be explained best by describing the facts that gave rise to this idea. When a toxin, say tetanus toxin, has been kept for some time, it is found that its toxic action decreases until relatively very large amounts are required to produce symptoms of tetanus in animals. Such a weakened toxin, however, requires just as much antitoxin to neutralize its toxic action as it did while possessed of its full strength. As the antitoxin is merely an accumulation of free receptors,

it seems that the toxin during the process of weakening has lost none of its power to unite with receptors, but rather has lost its power to cause injury to the cell. The group that attaches itself to the cell receptor has been called by Ehrlich the *haptophore* group, while the group that injures the cell is called the *toxophore* group. Toxins that have become weakened while still retaining their power to combine with antitoxin are referred to as *toxoids*, and are supposed to be toxins that have lost the toxophore group but have retained the haptophore group. In the diagrams of Ehrlich the fringed portion of the toxin figure represents the toxophore portion; the part fitting with the receptor, the haptophore.

It may be mentioned that this degeneration of toxins into toxoids has practical application in immunization, for since toxoids are just as capable of combining with cell receptors as are toxins, they can be used to produce anti-toxin without danger of causing intoxication.

The Relation of Toxins to Hemolysins.—While the above discussion of the nature of toxin and antitoxin does not directly apply to the subject of hemolysis, yet it is necessary to an understanding of the principles of cytolytic phenomena, since out of this conception of the nature of immunity against toxin has come our present conception of the nature of immunity against cells. Animals are immunized against foreign blood corpuscles just as they are against bacteria and against toxins, by repeated injections of small amounts of the foreign substance. Similarly in each case their serum comes to contain a substance capable of protecting the animal against the injected material. However, there is one important difference between immunity against toxin and immunity against cells, whether these cells are bacteria, blood or tissue cells matters not. To neutralize a toxin it is merely necessary to occupy the group of the toxin that unites with the cell receptors, for then the toxin cannot unite with the cells to injure them; in this harmless condition the toxin is destroyed or eliminated. In the case of the cells, however, it is necessary that they be destroyed by the serum, and this requires more than the entrance into them of some body from the serum; they must be attacked somewhat in the way a toxin attacks a cell. In fact, a serum immunized against a cell is really a toxin for that cell, and like the bacterial toxins it possesses two groups, one combining with the cell, and the other that attacks the cell. However, there are certain important differences between bacterial toxins and immune serums. It will be remembered that it was found that both bacteriolytic and hemolytic serums lost the power of producing their specific effects of cell destruction when heated for half an hour at 55° C., and that they regained this power in full when to them was added some normal serum, which alone was quite inactive. From this it was deduced that two substances enter into the cytolysis: one susceptible to heat and present in normal serum, the other more resistant to heat, and present only in immunized animals. Comparing the cytolytic serum with the toxin we see that the chief difference lies in the fact that one of the cytolytic bodies is present normally in the serum, and can be supplied quite readily to make the other body active. In its susceptibility to injurious agents and in its power to destroy cells this thermolabile substance resembles the toxophore group of the toxin. As it has to be added to the body that is developed during immunization to render the latter active, it has been given the name of *complement*, indicating that it is a complementary substance in the reaction. Another name sometimes applied to the same body, *addiment*, is of similar significance. On the other hand, the body developed in the serum through the process of immunization, is quite like the haptophore group of the toxin, in that it is more resistant to injurious influences, and, as will be shown later, is concerned in uniting the complement to the cell to be attacked. As it has two affinities, one for the cell, the other for the complement, it has been called by Ehrlich *amboceptor*, implying the double affinity. A receptor, for example, having but one affinity may be called a *uniceptor*. Another name commonly given to the amboceptor is *immune body*, because it is the specific substance that confers immunity; but, as this or a similar body may be naturally present in the serum of animals that have not been immunized, this name can be used only for specifically immunized animal serum, and the more general term, *intermediary body*, is used except in specific instances.

The Mechanism of Hemolysis.—Our understanding of the phenomena of serum hemolysis is therefore as follows: During immunization the immune bodies are developed, which have the property of combining with the red cells, attaching themselves to the receptors of the corpuscles. They combine on the other side with the complement that is present normally in the serum, even before immunization, and by so attaching it to the corpuscles enable it to exert its destructive action. This arrangement is indicated by No. 7 (Fig. 3122), in which the black fringed body represents the complement, united by the amboceptor to the red cell receptor. Beside it are shown free the two constituents of the hemolysin. Without being attached in this way the complement is quite inert. That the immune body is attached to the corpuscles is shown by the following experiment: If an immune serum is heated the complement is destroyed, and we have the immune body in an inactive condition in the serum. This inactive serum is mixed with red corpuscles, and kept for fifteen minutes at 45° C.; the red corpuscles are then separated by centrifugalization. The supernatant fluid is removed and added to other red cells. If it still contains intermediary body it should be able to dissolve the corpuscles when fresh normal serum, containing complement, is added. As no hemolysis does occur it appears that all the intermediary body has been taken out of the serum by the red corpuscles to which the serum was first added. That this is the case can be proved by adding to these corpuscles some normal serum which contains complement, but no intermediary body, for the corpuscles are now quickly dissolved. Therefore all the intermediary body must have been united to the red corpuscles during the fifteen minutes' exposure at 45° C. Another demonstration of this is made as follows: If just enough red corpuscles, heated immune serum, and fresh normal serum are mixed at 0° C. in the proportions required to saturate all the affinities and to leave nothing over, on removing the corpuscles it will be found that all the complement is in the supernatant fluid, and all the intermediary body is attached to the corpuscles. This indicates that the affinity of the intermediary body for the receptor of the corpuscle is greater than its affinity for the complement, and also shows that at 0° C. the complement and intermediary body can exist side by side without combining.

The foregoing are the fundamental facts concerning the mechanism of hemolysis, and the facts themselves are generally accepted. However, there are those who oppose the theory advanced by Ehrlich in explanation, contesting it on various grounds. For instance, by some it has been thought that the intermediary body acts after the manner of a mordant, simply modifying the cell so that it absorbs the complement, and all the features of hemolysis are considered manifestations of physical rather than of chemical action. Nevertheless, at the time of writing it has been possible to fit all the facts that have been developed into accord with the theory, and there is no question that the theory has been of immense value in giving a ground from which to proceed in new investigations of the laws and processes of immunity. In defending the theory, however, it has been found necessary greatly to amplify and modify the original simple conception

stated in the preceding paragraphs; and, as this process is still going on, it will be impossible here to give a complete account of all the changes so made. Considering each by itself, we shall make an attempt to give the chief facts concerning the two agents in the hemolytic process.

The Intermediary Body.—This factor in the cytolytic process has had an unfortunately large number of names applied to it, leading to much unnecessary confusion. Immune body and amboceptor have already been mentioned and explained. French writers often use the term, *substance sensibilisatrice*, with the view that its action is to prepare the corpuscle for the action of the complement. Rarely used now are the terms *fixator*, *desmon*, and *copula*. In general the name "intermediary body" (German, *Zwischenkörper*) is to be preferred, unless we are dealing with a specific substance obtained by immunization, when the term "immune body" may be used.

Its exact nature is totally unknown, for it has not been found possible to isolate it from other constituents of either serum or blood corpuscles. The fact that it is generally deprived of its action at about 70° C. would suggest that it is either a form of protein or is combined with one. However, thermolabile intermediary bodies have been described; like the complement they are destroyed at a lower temperature. The intermediary body does not seem to develop an affinity for the complement until it has first combined with the cell. Probably it unites with the stroma rather than with the hemoglobin, and it may produce some alterations in the corpuscles independent of the complement.

In immunization the body is formed in large quantities, much as is the antitoxin. As a rule the greater the difference in the nature of the animals used the greater the activity of the resulting serum. Rapid absorption of large quantities of corpuscles is also desirable, to which end the blood is usually diluted with an equal quantity of 0.75 per cent. salt solution and injected intraperitoneally. Immunization with either the stroma of red cells, or laked blood free from stroma, gives rise to hemolysins; but pure hemoglobin does not have as marked an immunizing power (Ford and Halsey). An ether-soluble substance, insoluble in acetone and hence resembling lecithin, has been extracted from erythrocytes, which also has immunizing power (Bang and Forssmann). Ehrlich explains the formation of the immune body on the same basis as the antitoxin formation is explained. In its ordinary processes of nourishment each cell must combine with protein molecules so large that in comparison with them the toxin molecules are small indeed. Such giant molecules cannot be used by the cell as they are, but are made available by means of a ferment-like process which splits them up into smaller fragments. This act is pictured as being accomplished by a group attached to the cell, which has one arm with affinity for the protein molecule and another for the ferment (see No. 8, Fig. 3122). In this way the protein molecule and the ferment are united in order that the protein may be acted upon. It will be seen that this is merely an amplification of the idea of the toxophore group of the toxin, which is attached to the cell by the haptophore group, in order that it may produce its injurious effects. In hemolysis the red corpuscle is considered in the place of the protein molecule, and in immunization against red corpuscles we simply have large quantities of such "side chains" as have this double affinity for corpuscle and ferment, cast off in numbers into the plasma. These side chains, then, are the intermediary bodies, which by the nature of their affinities are able to unite the complement to the red corpuscles and to accomplish their destruction. It has not yet been determined in just what cells or tissues the hemolytic amboceptors are formed, but it is known that they are not formed in the blood itself (Hektoen and Carlson).

Normal serum may contain bodies with the same properties as the immune bodies. For example, dog serum has normally considerable hemolytic action on guinea-pig corpuscles, and human serum on rabbit corpuscles. That this is due to the action of a true intermediary body is shown by the fact that when the serum is heated and the dog complement is destroyed, normal guinea-pig serum when added will furnish complement and hemolysis will occur. This also indicates that one particular intermediary body may unite with more than one sort of complement, for in this instance guinea-pig complement has taken the place of dog complement, and has united with amboceptors from dog serum. So far as we know, all varieties of animals may produce hemolytic amboceptors. Noguchi has demonstrated their presence, both normally and after immunization, in both vertebrates and invertebrates.

It is to the immune body that the specific action of immune sera is due. This may be shown by placing both chicken and guinea-pig corpuscles in a drop of serum from a rabbit immunized against chicken corpuscles. The nucleated corpuscles of the chicken can be readily distinguished from the corpuscles of the guinea-pig, and it will be found that they undergo hemolysis, while the guinea-pig corpuscles do not. It may also be mentioned that in this process the nuclei of the corpuscles are not dissolved, only the cytoplasm containing the hemoglobin being noticeably affected.

On the other hand, it is possible for a serum to contain at the same time a large variety of hemolytic amboceptors. These may be present normally, in which case the serum has the power to dissolve many varieties of corpuscles; or the same effect may be obtained by immunizing the animal with several varieties of blood at the same time. It has been shown that here we have not one amboceptor capable of uniting with all the varieties of corpuscle, but rather there is a special amboceptor for each variety. If one is removed by saturating with one sort of red corpuscle, the serum can still dissolve all the other sorts.

Another interesting feature of the immune body is that animals may be able to produce a body hemolytic for other individuals of their own species; for example, a goat immunized against the corpuscles of another goat may have its serum become hemolytic for the corpuscles of that particular goat. Such a lysin is called *isolysin*, as contrasted with the *heterolysins* formed when animals of different species are used. Of great importance is the fact that an *autolysin*, that is, a body causing hemolysis of the corpuscles of the animal providing the serum, cannot be readily obtained, although many experiments have been made to this end. It can be readily understood what serious results would promptly arise if such autolytic bodies were formed, and it has naturally been suggested that such a condition may exist in certain instances of autointoxication. In various diseases, moreover, Eisenberg found that *isoagglutinins* were present in very variable quantities, yet there were no instances in which the individual's serum was hemolytic for his own blood.

In *paroxysmal hemoglobinuria*, according to Donath and Landsteiner and others, the blood does contain an autohemolysin which will act upon the individual's own corpuscles and sensitize them for his own complement. This autohemolysin can react with the corpuscles only at low temperature, such as may be furnished in the peripheral vessels by exposure to cold, and the complements unite when the temperature of the sensitized corpuscles reaches 37° in other parts of the body. In susceptible persons attacks may be brought on by holding the hands in cold water, and their serum will sensitize human corpuscles *in vitro* at low temperatures.

The time required for the development of immune bodies varies greatly, as also does the time of per-

sistence after immunizing injections are stopped. In some instances hemolysins may be found as soon as a day after injection of corpuscles for the first time, and they are usually present in a week. In certain experiments of Ehrlich the time when maximum activity of the serum was reached varied from seven to fifteen days.

Bordet and other French observers have claimed that the union between amboceptor and corpuscle is not chemical but purely physical, but this contention is not accepted by Ehrlich and his followers. Ehrlich illustrates the resemblance of the reactions of intermediary bodies to known chemical substances by a comparison with diazo-benzaldehyde. By means of the diazo group the benzene radical may be united to one set of substances, such as phenols, aromatic amines, etc., while by the aldehyde group a different set of substances can be combined, including ammonia radicals and HCN. Thus by having the diazo-benzaldehyde as an intermediary body, phenol and HCN can be united, the phenol in this case assuming the place of the red corpuscle, and the HCN the place of the complement. In any event it seems certain that the union of the immune body is with the stroma alone, and as physical means have been found inadequate to cause the liberation of the hemoglobin it is apparent that some chemical change results.

Of the two combining portions of the amboceptor, the one that has an affinity for the complement is referred to as the *complementophile* group, while the one that unites with the cell is called the *cytophile;* or, in the case of hemolysis, as the *hemophile* or *hemotrophic* group. It seems probable that there are also intermediary bodies that have several combining groups, and are therefore not amboceptors, but triceptors, quadriceptors, etc.

By those who consider phagocytosis of particular importance in all processes of immunity, the observations of Savtchenko, that immune serum causes the phagocytes to engulf corpuscles with great readiness, is esteemed of much significance. This increased phagocytosis is manifested by leucocytes either in the body or in the test-tube, and may explain, at least in part, the increased phagocytosis observed in many diseases. It seems to be due, according to the observations of Hektoen, to an accumulation of specific *opsonins* in the blood; opsonins being those substances which render bacteria, corpuscles, and other cells susceptible to phagocytosis; they seem to be quite different from the other immune bodies.

Immune bodies are capable of transmission only in small amounts from mother to fetus, although there is no transmission from the male parent. A rabbit immunized before or during pregnancy to certain corpuscles may give birth to young possessing similar immune bodies, and it is possible for immune bodies to be transmitted by the milk, especially in the colostrum. Normally existing hemolytic and agglutinating properties may be transmitted from mother to fetus, but they do not necessarily agree in proportion in the blood of each; they are usually less in the fetus.

Complement.—Because of its property of causing solution phenomena in cells, whether corpuscles or other kinds, complement is generally considered as of the nature of a ferment, and this is supported by its susceptibility to heat, which is much the same as that of the known proteolytic enzymes; also it is largely held back by Berkefeld filters, and is destroyed by vigorous shaking. Many chemical agents, such as ten per cent. HCl, also destroy complements. Furthermore Delezenne has shown that the union of trypsinogen and enterokinase in the intestine, that results in the production of the active proteolytic ferment trypsin, is of exactly similar nature to the union of complement and immune body. On the other hand, after hemolysis of red corpuscles no bodies are constantly found that agree with those produced by either tryptic or peptic digestion, and the stroma is not ordinarily dissolved, but is deposited at the bottom of the test-tube as a sediment, still retaining some of its original form. In solution of red corpuscles by the known proteolytic enzymes the hemoglobin is attacked and much altered, while it is unaffected in serum hemolysis. Again, the hemolysin differs from a ferment, in that definite quantities of complement dissolve definite quantities of corpuscles, and do not have unlimited action as do the ferments; therefore it would seem that the complement enters into combination in the reaction in a way that ferments do not do. Certain compounds of soaps and proteins behave much as complement does, but it is probable that these do not correspond to true complement as concerned in immunity reactions. Some authors hold that the hemolytic complement may behave like a lipase, acting on the lipoids of the corpuscles (Jobling). Lecithin may behave much like complement with certain hemolytic agents, particularly cobra venom, but there is much doubt as to the justification of considering it a true complement (endocomplement).

The origin of the complement is unsettled, although there is much reason to believe that the leucocytes are one source, and perhaps the chief one. The complement content of peritoneal fluid seems to be increased if many leucocytes undergo dissolution in it, and this fact was the basis of the idea of a bactericidal substance, *alexin* (Buchner), that the leucocytes secreted. Ehrlich seems to have demonstrated that this alexin is the same as the immune body and complement, and not a single substance that by itself destroys bacteria. Aseptic inflammatory reactions have been found to increase both the bacteriolytic and hemolytic complement of the blood, although it cannot be demonstrated that the exuded leucocytes are rich in complement. It has also been found that the complement content of the blood in disease varies often in direct ratio to the amount of leucocytosis. Removal of the spleen does not prevent either the presence of complement or the formation of immune bodies in experimental animals (Levin). Complement is present in the serum of cold-blooded animals.

Undoubtedly there is more than one sort of complement, although at first Ehrlich thought that the complement was one and the same for all cytolytic processes. In some sera saturation of all the complement possible with one variety of amboceptor still leaves the serum containing complement that can dissolve corpuscles when the proper amboceptors are supplied. Again, serums have been found to possess complements with varying resistance to heat, some being indeed quite thermostable. In one serum, for example, immunized against a mixture of swine, sheep, and ox blood, Wendelstadt found that the complement for swine blood was more resistant to heat than that for ox or sheep blood, while the latter resisted HCl more. Normal horse serum was shown by Ehrlich to contain two complements; one specific for rabbit corpuscles, the other for guinea-pig corpuscles, which could be separated by filtering through a Pukall filter, as the guinea-pig complement alone passed through. This variability in filtration of complement indicates that the size or consistence of the molecules is not dissimilar to that of the enzymes, which are also variously held back by filters. Some complements have been found to diffuse through animal membranes, while others do not. It therefore seems that complement is not, as was at one time believed, a single, non-specific substance, but complements may be as numerous and as various as the intermediary bodies. However, one thing seems proved, namely, that the complement is not developed through the process of immunization, but is a constant constituent of the normal serum, although greatly fluctuating in quantity. In immune serum,

as a rule, the amount of complement is inadequate to saturate the immune bodies present. As before mentioned, this deficiency may be met by adding serum from animals not immunized —serum which contains complement. As a rule the normal serum should be from an animal of the same species as the immune animal, but it is a remarkable fact that a proper complement may be obtained for immune serum of one animal from an animal of an entirely different species. For example, serum of a dog immunized against the corpuscles of a guinea-pig, after being rendered inactive by having its complement destroyed by heat, may be again activated by addition of normal guinea-pig serum; that is, the guinea-pig complement will unite with the dog immune body as well as will the complement from the dog.

There are two groups in complement: one of which is united to the immune body, therefore a haptophore group, and another that acts upon the cell to which it is anchored, and called the *zymotoxic* group. This latter is analogous to the toxophore group of a toxin. As a matter of fact a complement is a toxin for the cell it may attack. As might be expected, therefore, just as toxoids are formed by degeneration of the toxophore group of the toxin, so also *complementoids* are formed by the degeneration of the zymotoxic group of the complement. It is generally stated that if serum containing complement be so treated as to separate the globulins from the albumin, it is found that the complement has been divided into two parts, one present in each of the protein fractions. The globulin fraction of the complement will unite to amboceptor which is fixed to cells, and hence is called the *mid-piece* of the complement, for it will unite also with the *end-piece* of the complement contained in the albumin fraction, and then cytolysis can take place. Without the intervention of the globulin mid-piece the albumin end-piece cannot unite with the amboceptor, while in the absence of end-piece the amboceptor mid-piece complex can cause no cytolysis. Both fractions of the complement are destroyed by heat, but if the mid-piece is bound to the amboceptor it resists heating. The mid-piece corresponds to Ehrlich's haptophore, the end-piece to the toxophore group, and this complex structure is common to both bacteriolytic and hemolytic complement. Bronfenbrenner and Noguchi, however, contend that the supposed cleavage of complement is merely an inactivation by the agencies employed, all the complement being in the albumin fraction in a condition capable of reactivation, not only by globulin but by simple amphoteric substances.

As before mentioned, the affinity between complement and intermediary body is less than between intermediary body and cell receptor, therefore the latter union occurs first. If the amount of intermediary body is largely in excess of the amount of complement the hemolysis is greatly interfered with, because the excessive intermediary bodies unite with the complement; and as the cell receptors have all been at once occupied by intermediary bodies, the complement cannot become attached to the cell, since intermediary bodies do not unite with each other. This blocking off is referred to as *deviation of the complement*, a term often incorrectly applied to the reaction of *fixation* of complement, as exemplified in the Wassermann reaction, which will be found discussed in another place.

Regeneration of complement after it has been exhausted takes place in a short time. In rabbits whose serum was deprived of complement by injecting goat corpuscles until the complement had all been absorbed by them, it was found that complete regeneration may take place in from two to four hours.

Although the complement is the normal, constantly present constituent of the blood that probably protects the body against bacteria and other injurious agents, yet it is also capable of being harmful to the cells of its own creator. Snake venoms, for example, seem to owe their poisonous properties to the presence of large numbers of amboceptors of various sorts, and therefore to produce their violently injurious effects they require the action of complement, which is furnished by the poisoned individual for his own destruction. It is probable that there are other conditions in which the complement is an agent of harm rather than of protection. In anaphylaxis, for example, the poisonous agent may be formed from the foreign proteins by action of complement.

The amount of complement in the serum of an individual varies in health, and even more so in disease. In phosphorus poisoning the power of the serum of the rabbit to destroy guinea-pig corpuscles is lost, because the corresponding complement is absent. Longcope claims that complement for typhoid and colon bacilli is decreased in many chronic diseases, which may account for terminal septicemia. Alcoholism is also said to reduce the complement of the blood of animals. Undoubtedly the fluctuation of complement content of the blood is an important factor in determining susceptibility to infection.

An indication of how purely chemical is the union between the various substances implicated in hemolysis is the observation by Hektoen that ions of Ca, Sr, Ba, and SO_4 combine in such a way with complement that it is unable to unite with the immune body, and thus they prevent hemolysis. These inorganic substances seem to saturate the affinity of the haptophore group of the complement in the same way that amboceptors do.

Antihemolysin.—Just as an antitoxin can be produced by immunizing cells against the toxins that injure them, so by immunizing the blood corpuscles against hemolytic serum an antihemolytic serum can be obtained. If heated serum is used in immunizing, an anti-immune body is obtained, that acts by combining with the cytophile group of the intermediary body and thus preventing the intermediary body and the corpuscles from uniting. If there are several intermediary bodies in the injected serum, antibodies may be obtained that are specific for each. These antibodies seem to be the receptors of the red cells that unite with the intermediary body in producing hemolysis.

By immunizing against normal serum, whether heated or not, *anticomplement* is obtained which also is specific. Ehrlich has shown that this anticomplement acts by combining with the haptophore group, thus preventing the complement from being anchored to the cell by the intermediary body. Such anticomplement does not unite at all with the intermediary body, which remains in a condition capable of taking up fresh complement if it is provided. Again, resembling the production of antitoxin with toxoids, anticomplement can be obtained by immunizing with complementoid.

Not only can *antiheterolysins* be obtained, but also *antiisolysins*, if serum hemolytic for blood of an homologous animal be used in immunizing. Since during normal conditions of life red corpuscles are continually undergoing dissolution, it may be that in every body there really develop autolysins, which are prevented from causing extensive destruction of the corpuscles by the production of *antiautolysin*. Besredka seems to have demonstrated the presence of such antibodies in normal serum, and suggests that such self-immunization may be an important process in protection of the body. In this connection it may be mentioned that there seem to be antiferments normally present in the blood that are perhaps of importance in preventing self-digestion of the tissues during life by the ferments of the body itself.

Agglutination in Relation to Hemolysis.—The well-known agglutinating reactions of bacteria can be duplicated with red corpuscles. As with bacterial agglu-

tinins the agglutinin seems to be, in Ehrlich's terms, a uniceptor; that is, it has but one group with affinity for other substances, as is the case with the toxins. Agglutinins for corpuscles are found to varying extent in normal serum, as well as in serums specifically immunized against the corpuscles. Heating at 55° C. does not destroy the agglutinin, and in this way the agglutination can be observed independently of the hemolytic processes. Agglutination also occurs at temperatures approaching freezing, when hemolysis is inhibited. Agglutinated red corpuscles collect in rouleaux and clumps that unite with considerable tenacity, so that ordinary shaking will not break them up. In hemolytic immune serum this agglutination precedes the hemolysis, but the two processes are quite unrelated. Normal serum may contain agglutinins and not be at all hemolytic, and the converse is also true. The mechanism of agglutination is not understood, but it is suggested that some chemical change in the substance of the corpuscle renders the surface adhesive, or that some physical change in surface tension accounts for the coaptation and adhesion of the corpuscles. As agglutination occurs in corpuscles that have been fixed in formalin or sublimate, it is probably not the protein of the corpuscle that is affected, but the other ingredients of the stroma, of which lecithins and cholesterol seem to be the chief. Flexner and Noguchi found that if ricin, an agglutinator, was allowed to act for two or more hours it is still possible then to produce hemolysis by serpent venom, but the stroma remains at the bottom as a white, conglutinated mass. From this it appears that agglutination brings about a kind of coagulation of the stroma. Bergel believes that hemagglutination is produced by a serum lipase, which alters the lipoid membranes of the corpuscles.

Agglutination of the corpuscles during life may be of some pathological importance, for such masses of agglutinated corpuscles could readily produce capillary thrombi and emboli, which, if widespread, might create much disturbance. Many bacteria produce substances that are agglutinative for human red corpuscles, among them being typhoid, pyocyaneus, and staphylococcus. Flexner has found in typhoid fever thrombi that seemed to be composed of agglutinated red corpuscles, almost free from fibrin and leucocytes. Probably many of the so-called "hyaline thrombi" found frequently in infectious diseases are really composed of agglutinated, partly hemolyzed red corpuscles. Pearce has found that agglutinative serum when injected into dogs causes widespread necrosis of the liver. The serum of one individual may agglutinate the corpuscles of another (isoagglutination) which is of great practical importance in the operation of transfusion of blood. Autoagglutination of a person's own corpuscles may also occur, especially when the blood is chilled in persons suffering from paroxysmal hemoglobinuria.

Agglutination is also produced by certain vegetable poisons, including ricin, abrin, and crotin, and these have been found to produce thrombi of agglutinated red corpuscles. Of these substances ricin alone, although strongly agglutinative, has no hemolytic action, showing the independence of the two processes. Snake venom, like most hemolytic substances, produces marked agglutination, and here also the agglutinin is distinct from the hemolysin. The seeds of many non-poisonous leguminous plants, and also of the *Solonaceæ*, yield strongly hemagglutinative extracts. Silicic acid and certain other colloids may act as agglutinins.

(3) Hemolysis by Bacteria.—Both pathogenic and non-pathogenic bacteria produce hemolytic substances that are excreted into the fluids in which they grow. During many infectious diseases marked hemolysis occurs, especially in those with septicemia. After death the hemoglobin of the blood goes into solution, and the resulting staining of the walls of the blood-vessels, and later of the tissues everywhere, is generally familiar. In the postmortem hemolysis probably the putrefactive organisms are chiefly concerned, although it is marked a very short time after death in many cases of septicemia, particularly when the infecting organism is the streptococcus, and here probably the pathogenic organism is the chief cause of the hemolysis. The hemolytic action of bacteria can be studied both *in vitro* and *in vivo*. Among the best known are *tetanolysin*, *pyocyanolysin*, *typholysin*, *staphylolysin*, and *streptocolysin*, as they have been termed. Of these the case of pyocyanolysin is questionable because it has been described as resisting heat over the boiling point, and Jordan seems to have proved that the hemolysis is ascribable to the alkalinity that this organism produces in culture media. Other bacterial hemolysins are, however, destroyed by heat at 70° C. for two hours; that is, they are altogether different from ordinary cellular hemolysins. G. Ruediger shows the following differences between streptocolysin and the hemolysins of serum: Streptocolysin is not destroyed at 65° C. for one-half hour, and therefore is different from complement. When destroyed by heating to a higher point it cannot be reactivated by the addition of complement, thus differing from intermediary body. It is also different from intermediary body in that it does not combine with corpuscles at 0° C.; on the other hand it does combine at 6° C., but does not exert any hemolytic effect until the mixture is raised to a higher temperature. This last observation indicates that the streptocolysin is similar in nature to the toxins, namely, a toxophore group and a haptophore group. In other words, streptocolysin is simply a toxin for red cells, which acts like bacterial toxins for other cells by joining directly to the cell receptors without the intervention of any intermediary body. As a similar structure has been shown for staphylolysin and tetanolysin, it is probable that the bacterial hemolysins are all merely toxins with a particular affinity for red cells, and against some of these bacterial hemotoxins antitoxic sera are said to be obtainable. Of course bacteria may also form many non-specific hemolytic substances, as products of their metabolism, such as acids and bases.

Secondary anemia of the infectious diseases is probably to be explained largely by this hemolytic property of bacterial toxins. Hemoglobinuria also may be produced in the same way. Intravenous injections of filtrates of the saprophyte, *B. megatherium*, will produce hemoglobinuria in guinea-pigs.

(4) Hemolysis by Vegetable Poisons.—A number of plant poisons are strongly hemolytic, and some of them owe their toxicity largely to their effect on the erythrocytes. One group, which includes ricin, abrin, crotin, robin, and phallin, is composed of substances supposed to be proteins, and called *vegetable toxalbumins;* of these crotin and phallin are most actively hemolytic, while with the others the agglutinating action is relatively more prominent. They resemble the bacterial toxins in that immunity can be secured against them, but they resist heating to 70° (except phallin). The activity of these toxalbumins may be realized if it is mentioned that purified ricin kills rabbits in doses of 0.000001 gram per kilo of body weight, and solutions of 0.001 per cent. agglutinate red corpuscles. According to the investigations of Ford and Abel the hemolytic poison of the poisonous mushrooms, the phallin of Kobert, is not a toxalbumin but a glucoside. Another quite distinct group of vegetable poisons with hemolytic properties consist of the *saponin substances*, of which there are many varieties widely distributed in the vegetable kingdom. Sapotoxin of soap bark is one of the best known. They are entirely different from the toxins, being heat resistant

and not giving rise to antibodies when injected; chemically they are glucosides. Apparently they produce their effect by acting on the lipoids, especially the cholesterin, of the corpuscles.

(5) Hemolysis by Venoms.—The hemolytic power of venom derived from different varieties of reptiles has been brought into the domain of biologic hemolysis, and the result has been not only an understanding of the mechanism by which the lethal effect of these poisons is produced, but also at the same time a new, easily controlled medium for research in problems of immunity has been provided. The most fundamentally important fact is the discovery by Flexner and Noguchi that the hemolytic and other toxic agents of venom themselves resemble true intermediary bodies. By itself venom is not hemolytic, but it requires the presence of a complementing substance to enable it to produce hemolysis, and as the venom contains no complement, this necessary part of the poison is furnished by the serum that contains the corpuscles. It is probable that many lipoidal substances, notably lecithin (Kyes), soaps and soap-protein compounds (Noguchi), may act as the complementing agent in venom hemolysis. The probable source of the intermediary bodies is apparently in the serum of the serpents, as if they were secreted directly from the blood into the poison glands, for serum of poisonous snakes is found to possess intermediary bodies almost identical with those of the venom. Venom from cobra, rattlesnake, moccasin, and copperhead possesses in each intermediary bodies that seem to be identical in nature, although they may vary in quantity. This explains the rather remarkable fact that serum of animals immunized against cobra poison, generally called *antivenin*, will neutralize the hemolytic and many of the other properties of the venom of rattlesnake, copperhead, and moccasin. Antivenin acts as an anti-intermediary body, and by occupying one of the haptophore groups of the venom keeps it from uniting complement and cell. In order of decreasing hemolytic power for mammalian corpuscles come venoms from cobra, water moccasin, copperhead, and rattlesnake. These venoms are also agglutinative for all corpuscles tried, and agglutination will occur at 0° C. Exposure for thirty minutes at 75°–80° C. destroys the agglutinative property. In general, the hemolytic power of the venoms for different sorts of corpuscles varies in inverse proportion to its agglutinative power. The hemolytic intermediary bodies are remarkably resistant to heat, suffering but slight loss of power at 100° C. Each venom contains many intermediary bodies, seemingly different for each sort of corpuscle hemolyzed, at least to a great part; no one sort of corpuscle can so saturate all the intermediary bodies that none is left for other kinds. After the intermediary body is attached to a corpuscle it can unite with many different sorts of complements, but only the one natural to its serum accomplishes complete hemolysis. Leucocytes also are dissolved, and they seem to have specific intermediary bodies different from those that unite with red corpuscles, but the agglutinin for each seems to be the same. As the venom contains large amounts of intermediary bodies, when an animal is poisoned by a snake the complement is quickly taken up, and this probably explains the deficient bactericidal power of blood serum in this condition that permits the extensive infections so characteristic of snake bites. Antivenin will prevent this interference with normal bacteriolysis by occupying one of the groups of the intermediary bodies of the venom so that it cannot use up the serum complement.

The erythrocytes of different individuals show considerable differences in their resistance to hemolytic agents, which has been made the object of some study as to diagnostic value. Thus, in syphilis the corpuscles show a heightened resistance to hemolysis by cobra venom, except in the earliest stages when they are hypersensitive. Also the serum of patients with various mental diseases inhibits the hemolysis of human corpuscles by cobra venom.

In passing it may be noted that the effects of venom on nerve and endothelial cells, which with the hemolysis constitute the manifestations of its toxicity, are produced in the same way as the hemolysis. Amboceptors are present that unite complement to these cells, enabling it to attack them. As certain venoms are richer in one sort of intermediary body than others, so the effects of the bite of one kind of snake differ from those of another kind, *e.g.* rattlesnake poison is particularly endotheliolytic, and therefore hemorrhages are a prominent sequence of the rattlesnake's bite.

Red corpuscles of the frog are not hemolyzed by venom, and those of necturus (mud puppy) but slightly, agreeing with the known resistance of cold-blooded animals to snake bites.

Eel serum is remarkably hemolytic, so much so that a quantity of 0.1 c.c. per kilogram of body weight will kill a rabbit or guinea-pig in three minutes when injected intravenously. Heating at 54° C. for fifteen minutes destroys the hemolytic action, and, unlike ordinary serum hemolysins, the addition of complement does not restore its activity. Animals can be immunized against this serum. Introduced into the stomach, eel serum is not toxic. It can be dried and redissolved without losing its activity, but acids and alkalies readily destroy it. Mosso, who first discovered the toxicity of eel serum, called the unknown active principle *ichthyotoxin*. Many other animals produce hemolytic poisons, *e.g.* spiders, bees.

Hemolysis in Disease.—During health there is always going on a certain amount of destruction of red corpuscles that have outlived their usefulness; so in disease we may have to deal with either an alteration in the normal processes of blood destruction, or the introduction of entirely new processes. Although the place and manner of normal red-corpuscle destruction is not completely known, yet it seems probable that there is relatively little hemolysis within the circulating blood. When a red corpuscle becomes damaged it seems to become more susceptible to phagocytosis, and it is picked out of the blood chiefly by the endothelial cells of the sinuses of the spleen, hemolymph glands, and bone marrow. Within these cells it apparently undergoes hemolysis. Eventually the resulting pigment is split up by the liver, the non-ferruginous portion forming the bile pigments, while the iron seems to be mostly withheld to be worked over into new hemoglobin. Whenever during disease red corpuscles are more rapidly injured than they are under normal conditions, these processes of normal hemolysis are exaggerated and we not only find the phagocytic cells of the spleen and glands packed with them, but endothelial cells elsewhere and leucocytes also take on the hemolytic function. At the same time there is an excessive production of bile pigment from the destroyed red corpuscles, which has an undetermined relation to the so-called "hematohepatogenous" jaundice. If hemolysis is very excessive the blood pigment accumulates in other organs than the liver and spleen. When at one time over one-sixtieth part of the hemoglobin of the blood is in solution in the plasma, it may escape in the urine, producing hemoglobinuria. It is said that both globin and hematin are toxic, and hence they may be responsible for some of the effects of hemolysis.

The hemolysis of the acute febrile diseases is readily explained by the demonstrable hemolytic property of the products of the organisms that cause them, such as streptocolysin, staphylolysin, etc. Perhaps at the same time altered metabolic products

may also play a part, but it does not seem probable from experimental results that the thermic condition *per se* has much effect. In malaria, although the parasites enter and destroy the corpuscles in which they live, yet this alone does not account for all the blood destruction of the disease, for the amount of anemia is quite without relation to the number of parasites to be found. There is good reason to believe that the plasmodia produce hemolytic substances that are discharged into the serum. In the primary anemias hemolysis seems to be the essential process, although the agents involved are at present unknown. Absorption of hemolytic products of intestinal putrefaction or infection has always come in for much suspicion, without ever becoming completely established. Here also the hemolysis seems to take place in the endothelial cells rather than in the vessels. In such a disease as pernicious anemia there is much reason to assume that defective or abnormal hematogenesis is an important factor. Probably the anemia of nephritis is the result of hemolytic action of the retained products of metabolism, in which connection the hemolytic properties of ammonium compounds may be recalled. In some diseases associated with anemia it has been found that the blood serum of the patient is distinctly isohemolytic, although isoagglutination seems to be more frequent. Such sera, however, do not seem to be autohemolytic, at least in the test-tube. The bloody fluids that can be obtained from cancers have been found to be hemolytic, while antihemolysin has been found in ascitic and pleural effusions. Autolyzing tissues produce hemolytic substances.

The resistance of the corpuscles to hemolysis by different agents varies greatly in disease, the difference being caused sometimes by changes in the permeability of the corpuscles, and sometimes by changes in their environment, or the presence of protective substances in either the corpuscle or the plasma. Cholesterol seems to be an important protective substance, and when the amount in the serum is increased the corpuscles become more resistant; if soaps, especially of the unsaturated fatty acids, are present in excess the corpuscles are more readily hemolyzed, since these are strong hemolytic agents.

In many forms of poisoning hemolysis is a prominent feature; in some it seems to be the chief effect of the poison, *e.g.* potassium chlorate and arseniuretted hydrogen. In severe extensive burns there may occur hemolysis, and hemoglobinuria may also result. The hemoglobinemia of "blackwater fever" has been the cause of much discussion as to whether the malarial parasite or the quinine is the cause, with a divided opinion resulting, although undoubtedly cases do occur in malaria without administration of quinine. After removal of the spleen hemolysis by the hemolymph glands exceeds that of the primitive spleen, causing an excessive destruction of red corpuscles (Warthin). This suggests that the spleen may normally dispose of some hemolytic agent which acts either by stimulating phagocytosis or by so altering the red cells that they are particularly susceptible to phagocytosis. However, it has been found that after splenectomy the corpuscles show a heightened resistance to hemolysis (Pearce).

As mentioned previously, resistance of corpuscles to various hemolytic agents varies in disease. They are said to be more resistant in carcinoma, syphilis and obstructive jaundice, and more easily hemolyzed in dementia præcox, anemia, and exophthalmic goiter.

The lesions produced in the organs of animals injected with hemolytic agents are usually pronounced and quite characteristic. There is often a subcutaneous edema, frequently blood-stained, and similar fluid may be present in the serous cavities. The fat is yellowish, and the muscles are darker in color than is normal. The spleen is usually much swollen, soft, friable, and very dark in color. The liver is usually swollen and mottled with red areas in a yellow background. The renal cortex is dark in color, even chocolate-colored, and the pyramids are comparatively light; in the urine is frequently hemoglobin. In the lungs are often hemorrhages or areas resembling small infarcts. The blood may be thin and even distinctly transparent. Microscopically the red corpuscles are found in all conditions of degeneration, and often fused together. In the liver, besides patches of congestion, fatty changes are present if the animal lives long enough. Large phagocytic cells packed with red corpuscles are abundant in the spleen, as well as diffuse accumulations of blood, often fused, and pigment both free and in the cells. Pigment also accumulates in the renal epithelium, which also often shows much disintegration; congestion is prominent and hemorrhages into both interstitial tissue and glomerules are frequent.

Bacteriolysis.—It is not our purpose in this article to discuss the specific microorganisms in this relation, but merely to indicate the relations of hemolysis and bacteriolysis. Whatever has been said in preceding paragraphs about the mechanism of hemolysis can be transcribed to apply to bacteria and bacteria-immune serum. Pfeiffer's observation of the solution of bacteria by serum of immunized animals was the precursor of the modern studies of hemolysis and the extension of Ehrlich's theory. Indeed the chief reason for the great interest in hemolysis lies in the understanding that whatever may be learned about hemolytic processes can be directly applied to the processes of immunity against bacteria. Therefore we understand that in the serum of an animal immunized against bacteria themselves, and not merely their toxins, there is present an intermediary body that is specific for the injected organism. This intermediary body attaches itself to the bacterium by one haptophore group, and with the other anchors the complement of the serum which then destroys the bacterium. Now as during immunization only intermediary bodies are produced in excess, while the complement is not increased, it often may be that defence may fail because of deficiency in the amount of complement. This possibly explains why it has so far been impossible to secure immune sera that will protect against bacteria as effectively as antitoxin protects against toxin, for with toxin no complement is required. The results of decreased complement content would be an increased susceptibility to infection, and this is seen in snake bites, when the venom uses up the blood complement and the patient often succumbs to bacterial infection after surviving the direct effects of the poison. In chronic diseases Longcope claims that in the later stages the amount of complement is much decreased, probably accounting for the occurrence of terminal septicemias.

It is probable that hemolytic complement is at least partly distinct from that causing bacteriolysis, and that complements for different bacteria can be separated from one another as well as from the agglutinins.

Welch has suggested that possibly the bacteria in their turn may develop antibodies to the tissues and fluids in which they are growing. If so, we have a reasonable explanation of the development of toxic substances with marked action on specific cells of the host, *e.g.* endotheliolysins, leucolysins, hemolysins; and also the peculiar manner in which bacteria often attack only certain tissues, *e.g.* multiple septic arthritis.

Cytolysis.—Red corpuscles being merely a particular sort of body cell it might be expected that lysins for other cells could be obtained in a similar manner, and such is the case. Such lysins are

called by the generic term *cytolysins*, or *cytotoxins*, and are specifically indicated by the name of the cell concerned, as endotheliotoxins or endotheliolysins, hepatotoxins, nephrotoxins, etc. The lysins or toxins in this case are similar in composition to the hemolysins, that is, an amboceptor and a complement group, and these groups are in all respects similar to the components of the hemolysins except that the cytophile group of the amboceptor is more or less specific for certain tissue cells rather than for red corpuscles. Such cellular toxins may be obtained by immunizing the animals against the tissue which is injected emulsionized into its peritoneal cavity; but, as with the hemolysins, they may occasionally appear in normal serums of various sorts of animals. It is by no means as easy to determine the results with tissue cells as with red corpuscles, where the liberation of the highly colored hemoglobin is easily detected. To some degree lytic changes can be observed in tissue cells under the microscope, but this is not usually very satisfactory. Another method of observation consists in injecting the immune serum into the body of an animal, and studying both the symptoms and the anatomic changes brought about in this way. The latter method has found the most general application. A disturbing element in all such experiments lies in the difficulty of securing tissue cells of one kind alone for injecting. For example, when hepatic-tissue suspensions are injected there are introduced at the same time endothelial cells, connective-tissue cells, and usually red corpuscles and leucocytes. Therefore an immune serum obtained in this way would contain immune bodies for all these cells, and it becomes impossible to ascribe any changes that follow its injection into an animal solely to effects of the hepatotoxins. While there are possible ways of avoiding many of these difficulties they have not been generally applied, and much of the earlier work is very questionable on this account. At the same time that cytolysins are formed agglutinins also appear, and agglutination of cells occurs as it does with bacteria and corpuscles. One of the earliest pieces of work in this direction was with sperm agglutinins, obtained by immunizing with sperm. Such serum, however, was not spermolytic.

It was at first believed that it would be possible to obtain immune serum so specific for a given organ or tissue that by injection of the proper immune serum a given organ could be thrown entirely out of function, but these ideas have not been realized, for immune serums as yet obtained do not show any high degree of specificity for the type of cells used in immunizing. The immune serums usually obtained do, to a certain extent, injure the specific organ, but they also often injure other organs as much or perhaps even more. Beebe claims to secure more specific sera by immunizing with the nucleoproteids of organs, but at the time of writing, this work has not been satisfactorily corroborated, Pearce and Jackson being unable to confirm it. In view of the elementary condition of cytolytic investigations, and the aforementioned sources of error in much of the work that has already been reported, I do not feel justified in this article in more than briefly discussing the specific results so far obtained. It should also be mentioned that recently some investigators who have used care in avoiding hemolysins, etc., in preparing specific sera have not been able to obtain as marked results as had been earlier reported.

Leucocytolytic Serum.—This may be obtained either by immunizing with leucocytes obtained from exudates or from the blood, or by using emulsions of lymph glands. The latter method introduces so many cells besides the lymphocytes that it is not desirable. Specific leucocytolytic sera agglutinate leucocytes and produce observable morphological changes, in the way of solution of the cytoplasm and cessation of ameboid movements. Of the leucocytes the large granular cells seem most affected and the lymphocytes least. When injected into the peritoneal cavity such serum causes an apparent initial leucopenia, and later a decided leucocytosis in the peritoneal fluid. Corresponding with this, if bacteria are injected at the same time as the serum, resistance is found decreased, but later it is much increased. Such serum also contains anticomplement, according to Wassermann, indicating that the injected leucocytes contain complement. Leucotoxin obtained by immunizing against lymphatic tissue is very thermolabile, being destroyed by 55° C. for thirty minutes, and the serum can be only partially reactivated by the use of fresh serum. Undoubtedly leucotoxic amboceptors are present in many normal sera, and their presence in the serum of certain cold-blooded animals and in venom has already been shown. Bacterial filtrates may also contain "leucocidins" analogous to the hemolysins.

Endotheliolytic Serum.—Every attempt at immunizing an animal with any sort of fixed tissue must of necessity involve the injection of endothelial cells as well as those specific to the tissue studied. Therefore it is possible that cytotoxic serum so obtained will contain endothelial toxins and so complicate any results of *intra vitam* experiments. There is every reason to believe that endotheliolytic substances are produced in this way. Ricketts found that serum of animals immunized against lymph glands was toxic to endothelial cells, which was indicated by hemorrhages at the point of injection, and marked desquamation of endothelium when the injection was made into a serous cavity. In snake poisoning the extensive hemorrhages are also due to an endotheliolytic principle, called by Flexner *hemorrhagin*. This is destroyed by heating at 75° C., and is particularly abundant, in fact the chief toxic agent in rattlesnake venom.

Lymphatolytic Serum.—This serum has been studied by Ricketts and by Flexner, immunizing animals with lymph glands. As might be expected from the nature of the injected glands the resulting serum contained endotheliotoxin, leucotoxin, hemolysin, hemagglutinin, leucoagglutinin, and precipitins. When injected into animals this serum had a marked effect upon the spleen and lymph glands, producing great enlargement of these structures, which were also congested. The bone marrow was also somewhat affected, and when marrow was used in immunizing, the *myelotoxic* serum produced marked proliferative changes in the lymph glands as well as in the marrow. The changes produced in the leucocytes were the same as those described for leucotoxic serum, indicating that the different forms of leucocytes can combine with immune bodies produced against lymphocytes. Leucotoxic substances are said to be produced in the blood of leukemic patients who have been treated with *x*-rays (Capps and Smith).

Nephrolytic Serum.—It has been claimed that if a kidney is destroyed by ligating its vessels or ureter the remaining kidney develops serious degenerative changes, which are not present if one kidney is entirely removed. This has been attributed to the development of nephrotoxic substances produced in reaction to the absorption of the injured renal tissue that has been left in the body. Other methods of renal injury have been thought to produce similar effects, and serum of animals with kidney disease was said to injure the kidneys of normal animals. From this basis it has been thought to explain the progressive nature of the chronic nephritides as the result of nephrotoxins produced through the absorption of the injured cells, and which nephrotoxins injure still other cells. Such a process, however, involves the production of cell toxins in an animal toxic for its own cells, that is *autocytotoxins;* and as it has so far been practically impossible to produce autolysins

of other sorts, it is not altogether probable that the kidney is an exception. Furthermore, Pearce was unable to produce *isonephrotoxins*, and could not corroborate the results said to have been found in the remaining kidney after ligating the vessels of the other. He did obtain an active *heteronephrolysin*, but also found that immunization with liver produced just as actively nephrolytic serum as immunization with kidney.

Neurolytic Serum.—Even as highly specialized cells as those of the nervous tissue seem to produce a reaction with the formation of immune bodies. Perhaps because any symptoms produced by action on the nervous system are so readily detected, and because of the advanced condition of our knowledge concerning the minute structure of ganglion cells, the results obtained with neurolytic serum have been particularly striking. Perhaps the most positive results are those of Ricketts and Rothstein, who found that serum of rabbits immunized against the brains or cords of guinea-pigs was highly toxic, when injected into the vessels of guinea-pigs, causing death with various symptoms only explainable on the assumption of nervous lesions. Microscopically the ganglion cells showed marked changes in those animals that survived the injection long enough. All the results so far obtained have been with heterogeneous serum. Venoms, particularly that of cobra, possess strong neurolytic substances, that are the chief toxic agents in most of the venoms (the rattlesnake excepted). This neurolysin can be removed by saturation with nervous tissue from the hemolysin, and conversely the hemolysin can be removed by saturating with red corpuscles, thus corroborating Wassermann's experiments with tetanus toxin and supporting Ehrlich's theory.

Thyrolytic Serum.—The report of Portis indicates that after removal of all hemolysis as a factor there do occur changes in the nature of excessive absorption of colloid, and proliferation after the order of that seen in regeneration. However, the clinical picture of thyroidectomy was not produced in any case, and the anatomic changes were not great. Beebe has secured an antiserum by immunizing with thyroid nucleo-protein which has been used in the treatment of exophthalmic goiter. MacCallum could not obtain an antiserum specific for the parathyroid.

Numerous reports may be found indicating attempts with varying success to obtain sera toxic for other tissues. Among them may be mentioned *epitheliolysin* (for ciliated epithelium), *spermatotoxin*, *hepatolysin*, *cardiolysin*, *splenolysin*, and *syncytiolysin*. Attempts at the production of immune serum with adrenal by Abbott resulted only in a serum with great hemolytic power, but with no particular effect on the adrenal. The principle in all is the same, but the results as a whole are not now in a state to warrant extensive consideration. In general, it can be said that it has not been found possible in this way to throw out of function one particular organ, with or without involvement of other structures. It must be borne in mind that we can have grave functional disturbances without corresponding anatomic alterations. There is no reason known why a group of receptors of essential importance to the functional manifestations of the cell may not be quite independent of vegetative functions; and with impairment of these alone there need be no visible cell changes.

H. Gideon Wells.

Bibliography.

A full discussion of the principles of immunity and hemolysis will be found in Rickett's "Infection, Immunity, and Serum Therapy," Chicago.

Excellent reviews bearing upon these topics, to which the reader is referred for the bibliography of the earlier works, are found in: "A Review of Current Theories Regarding Immunity," by James Ritchie, Journal of Hygiene, 1902, ii.; Ehrlich's "Croonian Lecture," in the Proceedings of the Royal Society of London, 1900, lxvi.; Kolle and Wassermann's Handbuch, 1913 (i.) 793, Landsteiner, Handbuch d. Biochem., 1909 (ii.), 395. Ehrlich's work will be found in detail in "Collected Studies on Immunity," translated by Charles Bolduan, New York, 1906.

References to the later literature of importance will be found in Wells' "Chemical Pathology," Philadelphia, 1914. Concerning cytotoxins see the compilation of literature by Sachs, Biochemisches Centralblatt, 1903, i., 573 *et seq.*; also the article by Sata, Ziegler's Beiträge, 1906, xxxix., 1.

Hemopericardium.—Under this heading are included only those cases in which there is a collection of pure blood in the pericardium. It is a rare condition and of but slight clinical interest. Those conditions in which there is a hemorrhagic exudate into the pericardium, such as may occur in tuberculosis or malignant disease of that sac, are not included in this title.

Etiology.—Hemorrhage into the pericardium may occur as a result of the following causes:

(1) As a result of traumatic injury from without, or by foreign bodies penetrating the esophagus from within. The injury may be limited to the parietal layer of the pericardium.

(2) Such hemorrhages have been found associated with scurvy, purpura, leukemia, and allied conditions.

(3) From the so-called spontaneous rupture of the heart wall such as may occur in fatty degeneration of the heart, acute and chronic myocarditis, abscess and single or multiple aneurysms of the heart. Coronary thrombosis with subsequent fatty degeneration of the infarction and primary and secondary malignant tumors of the heart wall have also been noted as causes. The lesion itself may be very minute so as to be found at autopsy only with difficulty.

(4) From rupture of an aneurysm of the aorta or pulmonary artery. The first part of the aorta is usually involved and it may be only by a pinhole rupture.

(5) From rupture of small vessels, namely, one of the coronary arteries, or of vessels in a new growth.

Anatomical Characters.—The quantity of blood varies greatly. It is greater when the opening into the aorta is small. When an aneurysm bursts into the pericardium the average amount of blood found is said to be about seven ounces. When the hemorrhage takes place through a small hole, it may reach twenty-four ounces. A traumatic case has been reported in which over six pints of thin, dark, fluid blood were removed from the pericardium in the course of three hours. The patient recovered. The blood may appear as a soft, red, jelly-like clot. A variable amount of serum may have separated from it.

Symptoms.—The condition may occur suddenly and the associated causative condition may or may not have been recognized. When the hemorrhage takes place through a large rent, immediate or very rapid death usually occurs, either from the effects of the hemorrhage or from paralysis of the heart. The symptoms are those of internal hemorrhage and the signs those of rapidly accumulating fluid in the pericardium. In those instances where the events do not take place so rapidly, there is cardiac oppression or pain, dyspnea and faintness. Naismith describes an epigastric pain which is said to accompany a slowly accumulating hemorrhage. In these cases also the disappearance of the apex beat, the weakening of the heart sounds and the enlarged area of dullness are much more apt to be made out. A single small lesion in the pericardium, healing rapidly without infection, may give practically no signs.

Prognosis.—The prognosis is bad when the condition is secondary to internal disease. It is not wholly so in traumatic cases and is gradually growing better with the perfection in the operative technique.

Treatment.—In the non-traumatic cases the treatment is limited to the relief of symptoms. The application of an ice-bag and the administration of morphine are always indicated. A few patients recover as a result of aspiration of the pericardial sac. The administration of cardiac stimulants may serve to prolong life in some instances. In the traumatic cases, in the presence of an *indicatio vitalis*, it is best to open the pericardium and attempt to repair the damage. This should not, however, be done until it is seen what the patient is apt to do. "Absolute rest and wait a little, but be ready." The first few hours are the most dangerous and if the patient survives them he is apt to recover without interference. The operative mortality is not high, the chief danger being postoperative pneumonia. If he recovers there is always the possibility that he will develop pericardial adhesions which may serve to impair cardiac action.

James Rae Arneill.

Revised by Ralph G. Stillman.

Hemophilia.—Hemophilia is an inherited disposition to bleed from the serous or mucous membranes, or from the skin, either as a result of slight trauma or spontaneously, together with pain and swelling of the joints, in which locality also hemorrhage usually takes place. The chief features of the disease are an hereditary disposition to uncontrollable bleeding.

Etiology.—The disease has been dealt with by many medical writers, but not till the latter part of the eighteenth century and the early part of the nineteenth century did it receive critical consideration. At this time the term "bleeder" was commonly used by the laity to designate those subject to the disease. This term was adopted by Otto in his writings—hemophilia being introduced by Schönlein. The cause of the disease is unknown. The theory of abnormally thin blood-vessels, as advanced by Virchow, has been disproven. A few cases show increase in blood pressure, and this finding was linked by Immermann to Virchow's observation upon the thinness of the blood-vessel wall; both theories have failed of proof. It is well to remember that the body is thoroughly guarded against undue strain; probably no safeguard in the body defences is more efficient. Every tissue has a reserve which, when compared with man-made machines, is enormous. The earliest influences which the body, in its process of development, was called upon to meet were violence and strain. In consequence every cell developed a resistance far beyond the ordinary demand. The liver, for example, was shown by Ponfick to be capable of functionating with only one-sixth of the whole organ intact. The heart, even of congenital deficiency, has an enormous resistance to strain. The mechanical or anatomical explanation of hemophilia—thin vessel walls and high blood pressure—has therefore the support neither of the findings in this disease nor in the behavior of tissues in general toward strain. One naturally turns for explanation to an infectious origin, but this is with even less support in fact than the anatomical or mechanical theory. In pernicious anemia there are a few experimental proofs (see *Pernicious (Addisonian) Anemia*, vol. i, p. 346) in support of the theory that a hemolytic agent is responsible for the blood destruction, but in hemophilia there is not a particle of evidence in either the clinical or pathological findings to support the theory that an infectious agent is responsible for the hemorrhages in that disease. Koch's contention that "nearly all the patients . . . have an enlarged spleen" is not borne out by autopsy findings. That pathogenic organisms are capable of producing hemorrhagic areas (petechiæ, purpura, etc.) is no evidence that similar hemorrhages in hemophilia have any relation to such infections. Koch states that he "considers hemophilia an infectious disease like scurvy" thus attempting to explain one unexplainable condition by another. The infectious origin of hemophilia must be dismissed as being founded upon purely theoretic ground and not very firm ground at that. It is one of the surprises that the student of medicine experiences that an investigator like Koch should so emphatically state infection as the proven etiology. The only theory which is supported by experimental or clinical evidence is that which attributes the uncontrollable bleeding to changes in the chemical composition of the vessel-wall fluids. The action of these fluids in hemorrhage occurring in the normal individual is to produce thrombi at the orifice of a broken blood-vessel, and thus plug the outlet. A clinical finding which is strong support of this theory is that the blood of hemophiliacs usually clots, outside of the body, in normal time. One must, however, take into account the diet, the time of taking the specimen, etc., in determining the coagulability of the blood. The tissue fluids responsible for the formation of thrombi at the orifice of a broken blood-vessel are thrombogen and thrombokinase which, in union, produce in the presence of calcium a fibrin ferment. A great reduction or absence of these fluids in the blood-vessels of the hemophiliac would cause a failure in the production of the necessary thrombi to check hemorrhage. Thus far this theory of Sahli[1] is supported by clinical, physiological, and chemical evidence. Upon these he goes on to build theories with regard to the hereditary feature of this disease and other clinical manifestations—all of which theories are unsupported by evidence. It will be seen, therefore, that Sahli's theory, if taken in conjunction with Virchow's observation on the blood-vessels of some of these cases, will indicate an abnormality of the vessel-wall in its structural and chemical make-up, and not primarily in any alteration in the blood itself or in the blood-making organs. The hereditary character and its curious disposition to transmission through the female remain wholly without explanation.

Symptoms.—Uncontrollable hemorrhage following some insignificant injury is the first symptom which suggests hemophilia. Add to this a family history of similar hemorrhagic tendency and the two most essential features are present. A question of great importance is from what portion of the body such hemorrhage may come. Is the tendency to bleed confined to groups of vessels—to vessels in certain tissues, or is the whole vascular system of a hemophiliac uniformly deficient? A patient of Agnew's, quoted by Osler,[2] bled from injury to vessels above the neck only. Bleeding from one kidney has been reported (Senator[3] Klemperer,[4] Grosglik[5]). Epistaxis is the form of hemorrhage in about fifty per cent. In twelve per cent. of the cases the bleeding occurred from the gums and intestines and in six per cent. the lungs, kidneys, and stomach were the seats of hemorrhage. Other locations are the joints, the uterus, skin, and conjunctivæ. The serous surfaces are rarely the location of hemorrhage, while the mucous surfaces are commonly so. Much has been written regarding the character of the hemorrhage; for example, bleeding has been described as "superficial" and "interstitial" and these have been further divided into "spontaneous" and "traumatic." These seem to be mere subdivisions without much clinical value, as in all probability injury, though slight, first induces hemorrhage in all cases. Some individuals are said to have a premonition of the hemorrhagic attack, such as nervousness, tingling, and a sense of foreboding, as is the case in the epileptic aura. If this be so the spontaneous hemorrhage must be admitted as occurring. These people, however, are for the most part nervous and fearful, both naturally and from the effects of gossip and conversation upon their tendency. Indeed it is possible that from early childhood in these hereditary

families the individual has heard hemophilia discussed. This is rarely the case with epileptics until actual seizures have occurred. The statement of hemophiliacs that they experience prehemorrhagic warning should be interpreted with caution. In deep-seated hemorrhages it is possible that what they interpret as prehemorrhagic is the sensation actually produced at the beginning of a slow hemorrhage. There is, therefore, no substantial proof of spontaneous hemorrhage.

The joints are usually painful and swollen, the knee and elbow being those most commonly affected. After the blood has accumulated and remained for a time in the joint, inflammation is likely to follow, though many hemorrhages into the joint may take place without any inflammation. In such cases the joint merely fills up, swells out and remains so until the blood is absorbed. Some thirty or forty such hemorrhages are reported, after which permanent deformity resulted. Ankylosis and deformity is the final stage of such joint invasion. It is very doubtful, whether any inflammation of the joint precedes the hemorrhage. The occurrence of joint involvement is probably the only clinical manifestation suggesting infection as being an etiological factor in this disease and has led some observers to consider a bacteriological agent as being the underlying etiology of the whole disease. It is yet to be proven that arthritis precedes the hemorrhage, or that even arterial disease of the joint exists. The joints are subject to constant and sometimes rough use, and it is but natural that the hemorrhagic tendency should find in this location a sufficient trauma to establish hemorrhage. Indeed one would select the joints as the portion of the body most open to the trivial trauma sufficient to produce hemorrhage in the hemophiliac. The presence of blood in the joint might act there as a foreign body inducing inflammation. The great difficulty which has been experienced in obtaining positive bacterial findings from joint exudates in many of the marked cases of arthritis would make the negative bacterial findings from these hemophilic joints of little diagnostic value. One cannot, however, dismiss infection from the list of theoretical explanations of hemophilia when one considers that many of the arthritides are now, after persistent search, being found to be due to bacterial invasion. In the case of hemophilia this explanation must be considered as wholly theoretical for with the presence of blood in the joint subsequent infection could readily develop and so cause and effect be easily confused.

The quantity of blood which one may lose and the duration of the hemorrhage are variously reported—not infrequently the amount is recorded in pounds, and the duration in days. Most of the subjects die in infancy; some reach early youth, but few attain adult life. A few reports mention those living to advanced years. The tendency to hemorrhage is said to decrease with increasing years. In the course of a hemorrhage a thinning of the blood often indicates that the bleeding is about to cease, and swooning and unconsciousness may precede a prompt stoppage of the flow. The viscera rarely present abnormal signs as due to or associated with this disease. Koch's statement that the spleen is usually enlarged has not received the support of clinical evidence. It would be more correct to state that the spleen is rarely enlarged. The blood pressure is reported in most cases as ranging between 110 and 125 millimeters of Hg. In a very few instances is it given as above 125 millimeters. The blood shows a reduction in the total white blood cell count with a relative increase in lymphocytes and a relative and absolute decrease in polynuclear lymphocytes. Megaloblasts and normoblasts occur according to the extent and duration of the hemorrhage. The serum and mineral constituents of the blood are normal, as is also the fibrin content. The blood plates are not diminished in number. The red cells are normal in number and shape until hemorrhage has continued for a considerable time. It will be seen from these reports that the blood does not differ from that of ordinary secondary anemia, and even such changes do not appear until after the hemorrhage has been going on for some time.

The coagulation time has been the subject of much discussion and investigation, and observers have reported very variable findings. This is due largely to the fact that the coagulation time varies according to the stage of the hemorrhage at which the specimen is taken. In order to ascertain the coagulating features of the blood in any individual case, the specimen must be taken from a fresh wound. Pratt[6] has emphasized this by the following statement—"A second drop of blood, obtained from a cut after the first drop has coagulated, always coagulates more rapidly than the first. This occurs also if the skin, after the removal of the first drop, is cleaned carefully with water, alcohol, and ether." Sahli has also called attention to the importance of estimating the coagulation time by a specimen from a fresh wound. In addition to the time at which the specimen was taken, the diet and drugs ingested and the temperature must be taken into account. That there is abnormality of the blood with regard to coagulation seems to be proven—retardation being greatest at the beginning of the hemorrhage and lessening in proportion to the length of time the hemorrhage has continued. Forty-five minutes and one hour appear not infrequently among the recorded coagulation periods. In one case of fatal hemorrhage (Goodall) blood from the femoral vein is recorded as having failed to clot.[7] The methods for determining coagulation time in the majority of observations are those of Wright and Vierodt. It should, however, be emphasized that as yet no systematic observations upon the coagulation time of the blood have been made with due regard to the period in the hemorrhagic attack at which the specimen was taken and with regard to the diet, the drugs, and the temperature. Until a large number of observations have been made with reference to these various factors, the question of the coagulability of the blood must remain incompletely answered.

The geographical distribution[8] and the relative involvement of the sexes is well shown in the following table by Grandidier:

HEMOPHILIA: GEOGRAPHIC DISTRIBUTION AND OCCURRENCE IN THE SEXES (GRANDIDIER)

Country	Bleeder.		Bleeders.	
	Families.	Bleeders.	Male	Female.
Germany	93	258	236	22
England	46	141	134	7
France	20	80	75	5
North America	15	61	60	1
Russia	7	11	7	4
Switzerland	5	48	48	
Sweden-Norway	3	9	6	3
Holland	2	9	7	2
Belgium	1	4	4	
Denmark	1	3	2	1
East Indies	1	6	5	1
Totals	194	630	584	46
			92.6%	7.4%

In studying this table, one cannot help but question whether a greater interest in the disease in Germany does not account for the preponderance of cases in that country. The same question cannot, however, come up with regard to the involvement of the sexes as the percentage of male sufferers (92.6 per cent.) is enormously in excess of that of the female (7.4 per cent.). The number of "bleeder" families now on record has reached a considerable figure, amounting to between 200 and 250; all of these records bear out the

fact that the females, although exhibiting no trace of the disease themselves, are the transmitters to the males, who manifest the features of the disease. Two of the most famous of these families are the Mampel family of Kircheim near Heidelberg, and the Appleton-Swain family of Reading, Massachusetts. The transmission through the various generations is shown by the family trees here reproduced.[9] In the case of the

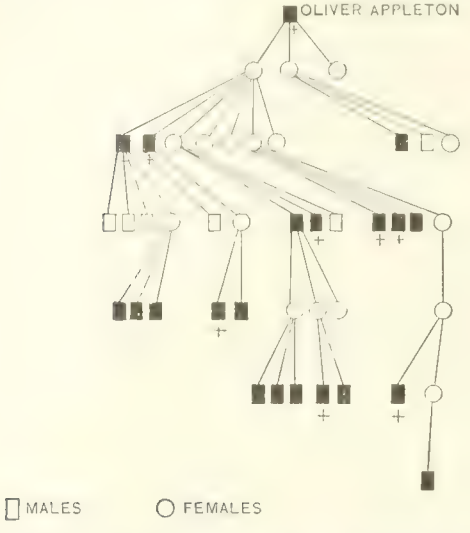


FIG. 3126.—Chart of the Appleton-Swain Family of Bleeders showing the transmission of the tendency to the seventh generation within 200 years. The black squares represent bleeders; those marked + died from hemorrhage.

Mampel family it presents perhaps the most trustworthy record, as the members of this family have been under careful observation for nearly a hundred years. It must always be remembered that in so spectacular a disease as that under discussion, superstition and gossip may enter into many of the records. It would appear, however, that the tendency to bleed dies out, having its greatest activity in the first four or five genera tions, and extends, in rare instances, as far as the seventh generation.

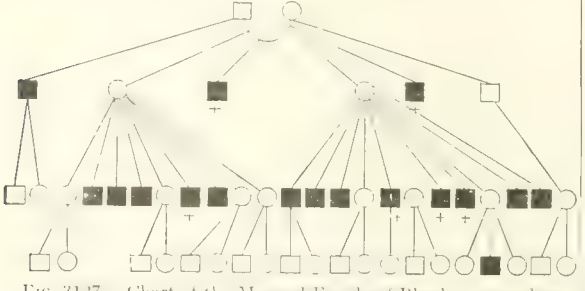


FIG. 3127.—Chart of the Mampel Family of Bleeders, according to Lossen. The black squares represent the bleeders; the members designated by + died from hemorrhage.

DIAGNOSIS.—The condition is not difficult to diagnose. Petechiæ, purpura, and arteriosclerotic bleeding from the nose and throat should cause no confusion. Hemophilic hemorrhages always occur *at the time* of the trauma, have a marked tendency to recur and are more profuse and uncontrollable than any other known bleeding. One case (under the author's observation) of bleeding following tonsillotomy occurred several days after the operation. The child nearly died from loss of blood which was found to be due to the separation of a scab, twice in succession, from the same point. The length of time at which the hemorrhage took place after the operation proved that this child was not a bleeder. The diagnoses of hemophilia should not be made on the strength of a single hemorrhage. The bleeder always exhibits a tendency to recurring hemorrhage.

PROGNOSIS.—Prognosis is unfavorable. Death before the eighth year is common, occurring in about 60 per cent. of the cases. The prognosis is better as more advanced years are reached, but the hemorrhagic tendency is rarely outgrown. Few die in their first hemorrhage.

TREATMENT.—It is very doubtful whether any of the drugs or measures recommended are in themselves sufficient to check the hemorrhage. Prophylaxis occupies an important place in the care of these individuals. Prophylactic measures consist of the avoidance of situations which may produce traumata and in the administration of horse serum before even slight operations; in the latter procedure small doses of serum should be administered at intervals some time before the date of the operation, and serum should be in readiness for administration at the time of the operation, should hemorrhage threaten. *In the administration of serum great care should be exercised* with regard to the possibility of an anaphylactic reaction. The ordinary measures exercised in the checking of hemorrhage should, of course, be employed. The use of calcium lactate and of gelatin has been warmly recommended, but it is very evident that the drugs and measures mentioned by the writers on this subject are merely enumerations of trials made with various agents, no one of which has been proven to act certainly and uniformly in all cases. Until it is determined what the body lacks in these individuals and until a means of supplying this lack is discovered, remedies must be employed empirically. It should be remembered that these individuals can lose large quantities of blood without a fatal termination necessarily taking place and that there is no evidence in these cases of disease of the blood-making organs. The realization of these two facts should make one persist in the effort to check hemorrhage by the ordinary hemostatic means. Some writers warn against the subcutaneous administration of gelatin on account of the possibility of severe hemorrhage being induced by the puncture and also because of the danger of tetanus, the organism of which occurs in gelatin and resists the ordinary antiseptic precautions; gelatin by mouth is, however, quite harmless.

The treatment of the joint affections is as unsatisfactory as that of the hemorrhage. Affections of the joints in hemophiliacs should be considered as occurring in three stages. The first is that of ordinary hemorrhages into the joint. With the application of non-irritating substances and the protection of the joint, the blood which accumulates rapidly, deforming the joint, may be absorbed, and the joint become normal. In the second stage, inflammation may be set up, and the outcome, as in all arthritides, depends upon the organism invading the joint tissues; such joints usually resist all treatment and the joint remains swollen and goes on to the third stage of ankylosis. In the first stage repeated hemorrhages may occur, the blood being absorbed and the joint recovering with little or no impairment. Forty such hemorrhages are reported to have occurred within a single joint, with no evidences of permanent deformity until the last few hemorrhages occurred. C. N. B. CAMAC.

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Hemoptysis.—The term hemoptysis (*αἷμα*, blood, *τύσις*, spitting) is used technically to indicate bleeding from the lungs or bronchial tree. Blood that is expectorated may come from other sources, especially the nose, pharynx, and gums, but such cases are not commonly included under this caption. Parasitic hemoptysis, caused by the presence in the lungs of the lung fluke, *Paragonimus westermanni*, is a special variety.

Etiology.—The cause of hemoptysis may lie in the condition of the vessels, in the elements forming the blood-clot, or in the blood-pressure. As to the vessels, the bleeding may occur from either the pulmonary or the bronchial arteries, veins or capillaries. Of the elements forming the clot, attention has been paid to the contents of calcium salts, thrombokinase, antithrombin, and prothrombin, but these studies are only beginning to be of practical value. The platelets, the clotting period, and the bleeding time have been studied, thus far without practical result.

Hemoptysis usually means tuberculosis, but not invariably. The laity has come to recognize pretty commonly the frequency of tuberculosis in the etiology of hemoptysis. The modern physician, though not overlooking the frequency of tuberculosis in these cases, should be able to recognize the non-tuberculous cases of hemoptysis.

Aside from tuberculosis, there are numerous less frequent causes of hemoptysis. Mention has been made of the parasitic form. Trauma is a common cause, usually easy of recognition. Hemoptysis due to change in altitude is common, and is of special interest to the tuberculous patient contemplating a change of climate. The hemoptysis of pneumonia is characteristic. Pulmonary congestion with infarction, observed often in cardiac disease, especially in those cases in which the mitral valve is most affected, is probably next to tuberculosis in the causation of hemoptysis. Aortic aneurysm is a not infrequent cause and should not be overlooked. The various forms of the hemorrhagic diathesis may show hemoptysis. Thus hemoptysis may occur in hemorrhagic smallpox or any form of severe purpura and in hemophilia. Abscess or gangrene of the lung may show traces of blood in the sputum. New growths are possible but rare causes of hemoptysis.

Hemoptysis sometimes occurs as an expression of vicarious menstruation.

In all cases hemoptysis should be differentiated from hematemesis, especially the vomiting or regurgitation of blood from ulcer or malignant disease of the esophagus or stomach. Hemorrhage from the pharynx may be recognized by inspection. In excessive hemoptysis, considerable quantities of blood are swallowed, to be later vomited (hematemesis) or passed as tarry stools (melena).

Symptomatology.—The hemorrhage of hemoptysis varies greatly in both quantity and character. Blood may appear in the sputum only in microscopic quantity, the sputum may only be streaked with blood, or the quantity of blood lost may be sufficient to cause syncope. The blood may appear in the sputum in specks or streaks, or it may be intimately mixed with the sputum. The color may vary from bright red to a red that is so dark that it appears almost black. The rusty sputum of pneumonia and the reddish-brown or brick-dust-colored "anchovy sauce" sputum of amebic dysentery, are characteristic. The latter is found especially in the cases of amebic abscess of the liver discharging through the lung.

Diagnosis.—In hemoptysis, the clinician thinks first of tuberculosis. Often there are no gross pulmonary physical signs observed for some weeks after hemoptysis first occurs in cases of tuberculosis. So that the diagnosis in these cases must rest upon a thorough examination, including the examination of the sputum and the tuberculin test. Nor must we be deceived by the appearance of the patient. Hemoptysis is especially prone to occur in the full-blooded incipient cases of tuberculosis, patients that present otherwise the appearance of perfect health, with color and weight above the average, well-developed musculature, and a history possibly of never having been sick. The sputum of such a case may contain myriads of tubercle bacilli. To make the diagnosis, it is a good rule to subject the sputum to an examination for the tubercle bacillus in every case of hemoptysis.

Hemoptysis and pulmonary hemorrhage are not synonymous; either may occur without the other.

The blood may come from the larynx, more frequently from the bronchi. Filarial hemoptysis has been referred to. Hemoptysis sometimes is observed in hysteria, in which cases hysterical hemoptysis must be differentiated from attempts at deception. Such patients frequently obtain the blood from other sources, notably the gums and pharynx, apparently craving the attention that is usually bestowed upon cases of hemoptysis. Hemoptysis may occur in aneurysm of the aorta, bronchiectasis, brown induration of the lungs, typhoid fever, influenza, and pulmonary syphilis.

In pulmonary tuberculosis, hemoptysis may occur from congestion very early in the course of the disease. Later hemorrhages are usually due to erosion of blood-vessels, and the quantity of blood lost is determined largely by the size of the vessel from which the hemorrhage occurs. The blood-vessels are often weakened or aneurysmal in the cases showing traces of blood in the sputum.

Microscopic traces of blood may be found in the sputum in practically all ulcerative cases of pulmonary tuberculosis, and there is the gross appearance of blood in the sputum in about two-thirds of the cases. A predisposing influence has been ascribed to general humidity of the atmosphere. At any rate cases of hemoptysis are prone to occur in groups.

Hemoptysis sometimes occurs as the first intimation of pulmonary tuberculosis. In such cases the bleeding may be slight or profuse. Hemoptysis, especially severe pulmonary hemorrhage, is far more frequent after the formation of cavities in the so-called third stage of tuberculosis.

Aside from the weakening and erosion of vessels, increased blood pressure is an important factor in etiology. Among the important exciting causes of hemoptysis are excessive coughing or physical exertion, periods of anger or excitement, and the inhalation of gases or vapors.

The site of the hemorrhage in pulmonary tuberculosis may usually but not invariably be determined by auscultation, bronchial rales occurring over the infected area. Such rales may be absent in true cases of pulmonary hemorrhage, or they may be present in the absence of hemorrhage from the lungs.

In bronchiectasis the sputum may be streaked with blood or there may be profuse hemorrhage. Two instances of fatal hemorrhage in bronchiectasis have been observed by Barth.

There is often hemoptysis in brown induration of the lungs, and the bleeding may be free in the cases dependent upon mitral regurgitation. Usually there is merely the spitting of blood for a protracted period. There is more danger from sepsis and toxemia than hemorrhage in these cases, the blood making a more favorable soil for the growth of microorganisms.

Laryngeal hemorrhage may be due to syphilis, tuberculosis, malignant disease, the presence of a foreign body, the so-called hemorrhagic diathesis, cirrhosis

of the liver, pregnancy, vicarious menstruation, etc. Among the exciting causes are excessive coughing, vomiting, or singing, and violent exercise that tends to raise the blood pressure. Laryngeal hemorrhage due to erosion is usually caused by a lesion at the posterior insertion of the vocal cords or on the anterior face of the arytenoids.

The hemoptysis of laryngeal hemorrhage is usually small in quantity, the blood appearing in small particles in the saliva. The color is usually bright, but small dark-colored clots may be expelled. There is rarely profuse bleeding, but dyspnea may be caused by the formation of a clot that occludes the respiratory passage.

Prognosis.—This varies with the cause. In pulmonary hemorrhage the immediate prognosis is usually good, though the bleeding may be so severe as to cause syncope. The ultimate prognosis of hemoptysis in pulmonary tuberculosis depends upon a number of factors, chief among which are the prostration of the patient and secondary infection due to the growth of microorganisms upon the clotted blood in the lungs. Furthermore there is a tendency to a repetition of the hemorrhage in tuberculosis.

The immediate outlook in the hemoptysis of mitral disease is usually good. Pulmonary infarction with infection in these cases may later give a grave prognosis. Hemoptysis due to aortic aneurysm presents a grave outlook. In the various forms of the hemorrhagic diathesis, the prognosis of hemoptysis is that of the underlying condition and is not good. The grave hemorrhagic infections, in which hemoptysis occurs, afford an unfavorable prognosis. In the hemoptysis of vicarious menstruation the outlook as to life is good and often such cases cease spontaneously.

The ultimate prognosis is bad, depending upon the cause, in the hemoptysis of pulmonary abscess, gangrene, and new growths. In traumatic hemoptysis the outlook is usually good, but not invariably without gravity. In such cases there is usually more danger from sepsis than from the hemorrhage *per se*.

Treatment.—In the treatment of hemoptysis, rest is a *sine qua non*. This may be best obtained by placing the patient in a recumbent or semi-recumbent position. The hypodermic use of morphine and atropine has probably come into vogue largely because these agents tend to quiet the patient and thus secure more complete rest. Strapping the chest is a valuable procedure for the same reason.

To assist in the formation of the clot, coagulose, the precipitated normal blood-serum containing fibrin ferment, is of especial value in cases of hemophilia. The calcium salts, especially the lactate of calcium, may be given in a dose of sixty grains with the beginning of the hemorrhage, repeated in three or four days. There is no known satisfactory remedy that acts by constricting the bleeding vessel in the lung, save possibly the ice-bag. The pituitary extract apparently raises the body blood-pressure and reduces the pulmonary blood-pressure.

At the time of the hemorrhage the patient may take a tablespoonful of common salt with as little water as possible. Sometimes dyspnea is best relieved by champagne. In the presence of great dyspnea in severe bleeding, it may be necessary to remove clotted blood from the throat and larynx. It may be advisable to ligate the extremities. Persistent cases may be controlled by compression of the lung, which may be secured by the injection of oxygen or nitrogen gas into the pleural cavity. Where only temporary pressure is necessary, ordinary oxygen gas may be injected, when more lasting pressure is needed, nitrogen gas should be used. In all cases of hemorrhage the patients should observe absolute rest in the recumbent or semi-recumbent posture, and should remain in bed a week after the last trace of hemorrhage. The application of the ice-bag to the chest is recommended, out of deference to custom, and the patient is directed to swallow pieces of ice. Thirst is relieved by cold drinks. The use of tannin, which has been recommended as a spray and by internal administration, upon theoretical grounds, is of very doubtful value. Atropine may be administered in doses of gtt. iii.–v., of a solution of gr. i. to ʒi. every three or four hours until the bleeding stops, or up to tolerance. Nitroglycerin may be given, one-half drop every half hour. Cough should be relieved by opium, best in the form of Dover's powder, gr. ii.–iii. every two or three hours.

Ergot, in the form of the fluid extract, a teaspoonful every hour or two, has been recommended, but is not so good as atropine.

Aconite has been used as a cardiac sedative. Hydrastis canadensis is considered an important remedy. In the presence of fever, quinine may be given, gr. v. every three or four hours during the continuance of the hemorrhage. Ipecac may be administered, gr. xv. every ten minutes (Trousseau), or, to avoid vomiting, it may be given in smaller doses, gr. i.–ii. (Jaccoud) every half hour, then every hour and then every two hours, taking care to avoid nausea. The use of antimony and potassium tartrate has been recommended (Peter), gr. $\frac{1}{60}$ every two hours until nausea is produced, when the hemorrhage may be stopped by an energetic contraction of the blood-vessels. Potassium bromide may be given with digitalis, especially in the presence of nervousness, as at the menstrual time.

George E. Malsbary.

Hemorrhage.—From αἷμα, blood, and ῥήγνυμι, to break through. The blood may escape from the arteries, veins, or capillaries, and from its origin the hemorrhage is designated as arterial, venous, or capillary.

In arterial hemorrhage the blood escapes from the arteries in jets synchronously with the contraction of the left ventricle, and flows continuously during diastole. The blood is then of a bright or pale red according to the quality. In dyspnea it is dark in color.

In venous hemorrhage the blood escapes from the veins in a continuous stream or in feeble jets and is dark in color. In capillary hemorrhage the blood oozes from a smaller or larger surface and is reddish in color.

Secondary hemorrhage occurs from one to eight days after operations, and may be due to slipping of a ligature or separation of a slough or dislodgment of a thrombus. It is especially liable to occur in infected wounds. Long continued, increased, intravenous pressure causes dilatation of the veins and may be followed by rupture, as seen occasionally in the veins of the leg and in the esophageal veins in cases of hepatic cirrhosis.

Just what are the alterations in the blood that favor hemorrhage are not definitely determined, but the white corpuscles are greatly increased in numbers and the time required for coagulation is increased. The coagulation time may be determined by the coagulometer; normal blood clots in the tubes in from three to five minutes. In some forms of purpura the coagulation time is retarded to ten or fifteen minutes, and in hemophilia it has been delayed as long as fifty minutes (Osler).

These changes in the constitution of the blood, which lessen its coagulability and thus favor hemorrhages, obtain particularly in leukemia, purpura, and prolonged icterus, especially if associated with malignant disease.

Of recent years there has been an increasing tendency to regard the spontaneous hemorrhages occurring in new-born children as a manifestation of microorganismal disease. Hemorrhages from changes in the blood, as in leukemia, have long been recognized. Many of the hemorrhages occurring from the mucous membrane, especially that lining the stomach and

intestines are now regarded as due to an infection originating in the gall-bladder, vermiform appendix, or other part of the intestinal canal.

Consequences.—Repeated small hemorrhages may gradually bring about a profound degree of anemia. Large hemorrhages result in anemia but they are also followed by a condition of shock. The severity of the symptoms is greatly increased if the bleeding takes place rapidly. It has been shown conclusively that death from hemorrhage takes place in consequence of a lowering of intracardiac and intravascular pressure, incompatible with the continuance of the function of the circulatory organs.

Hemorrhage may result disastrously, not only from the loss to the individual of a large quantity of blood, but also from the pressure of the escaped blood on adjacent structures. This is notably the case in intracranial and pericardial hemorrhages.

Symptoms.—The symptoms may vary with the rate and quantity of blood lost. In repeated small hemorrhages anemia is the obvious result. The objective signs are pallor of the skin and mucous membranes, coldness of the surface, the degree of anemia present being accurately determined by a blood count. It is, of course, evident that a much greater quantity of blood may be lost in small quantities and at intervals without a fatal result than in one or two large hemorrhages. In the former instance repair is constantly going on and the system acquires toleration.

When a large quantity of blood is lost rapidly, faintness and pallor of the skin and mucous membranes are the first symptoms to attract notice. If the bleeding continues the pulse becomes soft, small and compressible. The blood pressure is lowered. The face and extremities become cold, the respiration rapid, shallow and sighing, and "air hunger" is complained of because the supply of oxygen to the tissues is limited in proportion to the decreased volume of blood circulating through them. There is great restlessness. Finally noises are heard, the pupils dilate and the sphincters relax.

Children bear loss of blood badly but make it up quickly. Adults, and especially old people, are slow to recover great loss of blood. There occurs a marked leucocytosis. In six or eight weeks a child can recover from a considerable loss of blood. In older people, while the water, albumin, and salts are quickly replaced from the tissues, yet the red bone marrow of the long bones and vertebræ only slowly restore the red blood cells, and old people, as a rule, after a large hemorrhage remain permanently more or less anemic.

Women, during the child-bearing period, seem able to survive very large losses of blood and to recover quickly and satisfactorily.

At other times the evidences of hemorrhage are to be sought for in focal lesions of the brain or in the presence of physical signs of fluid in the pericardium, in the pleura, or in the abdomen.

It is not always easy to differentiate the symptoms of acute anemia the result of a large concealed hemorrhage, from shock due to other causes. Reliance must be placed upon the history of the onset, and the exclusion of other causes of shock, such as fright, local injuries to important organs, extensive superficial burns, severe pain, and the presence of the physical signs of fluid in the great cavities of the body.

Treatment may be prophylactic, constitutional, and local.

Prophylaxis.—The value of calcium chloride as a preventive and curative agent has been questioned. Blood containing less calcium than normal coagulates slowly. To supply an additional quantity in hemophilics and to patients for a long time jaundiced, seemed rational. Some surgeons have expressed disappointment with the results. It probably cannot do any harm. If employed as a prophylactic thirty grains should be administered by mouth every four hours for a day or two before operation and continued in the same dose, either by mouth or per rectum, for a couple or three days afterward.

Before beginning an operation usually attended by considerable hemorrhage, some surgeons have made it a practice to introduce into the circulation through a vein or subcutaneously a liter of normal saline solution

In operations upon an extremity much blood can be saved by previously placing around the limb an Esmarch elastic band. The constricting band should be two inches or more in width and so placed that important nerves shall not be unduly pressed upon. Negligence of this precaution has occasionally resulted in a more or less persistent paralysis of the parts below the elastic ligature. There is no object in applying this bandage too tightly. Sufficient pressure to arrest the circulation in the arteries is better than more. Before applying the Esmarch band the limb may be elevated for a few minutes. Force of gravity will materially lessen the quantity of blood in the vessels. It is not usually wise to bandage the limb before applying the constrictor; by so doing septic matter might be forced along the vessels into the circulation. Troublesome oozing is apt to follow the prolonged application of Esmarch's elastic band. It is due to a degree of vasomotor paralysis of the smaller vessels. Sometimes free and troublesome oozing follows the removal of the bandage.

Temporary ligation of vessels may be practised with safety. Senn states that a temporary ligature may be left on a vessel for twenty-four hours without permanent injury, provided the ligature is not drawn tight enough to injure the intima. He has frequently placed temporary ligatures on the carotid at the level of the lower border of the thyroid cartilage, before operating on the parts above. He refers especially to operations performed on the pharynx, parotid, and submaxillary regions. He places a double ligature, which, if need be, can be made permanent. Temporary may well replace preliminary ligature of large arteries in suitable cases.

Momburg's constriction of the abdominal aorta by a soft rubber tube passed around the body midway between the border of the ribs and the iliac crests, and drawn sufficiently tight to arrest the pulsation in the femoral artery, enables the surgeon to operate in the pelvis and on the lower extremities without hemorrhage. Constricting bands are also applied around the thigh below Poupart's ligament and others around the legs just below the popliteal spaces. The order of removal of the constricting bands is important. The band around the body should be removed first, then one of the thigh bands, then one of the leg bands, etc., the object is to avoid too sudden and too great stress upon the heart.

Constitutional Measures.—Many drugs are held in high repute as hemostatics. Mention may be made of aromatic, sulphuric, tannic and gallic acids, spirit of turpentine, ergot, acetate of lead, and opium. Some act by producing clotting, some by stimulating the vessels to contract, and opium by equalizing the circulation and thus lessening intravascular pressure at the bleeding point. Turpentine has many advocates. It may be given three or four times daily in doses of ten to fifteen minims. In hemorrhage from the intestinal mucous membrane opium has been found very useful.

Suprarenal capsule is now being used as a styptic. Its active principle is called adrenalin. Powdered suprarenal capsule may be used locally or may be given internally in doses of two to five grains. Adrenalin is very readily oxidized, and is on the market in solution. That prepared by Parke, Davis & Co., is adrenalin chloride 1 to 1,000 of physiological saline solution. Its permanence is maintained by the addition of 0.5 per cent. of chloretone. It may be used locally or

internally in doses of five to thirty minims. Locally it acts in very weak solution. A solution made by adding one part of the 1 to 1,000 solution to one thousand parts of sterilized physiological salt solution is an effective local astringent. Powdered suprarenal body and its active principle adrenalin act by causing the contraction of the walls of the vessel. Evidence of its effectiveness is accumulating daily. The writer has found it most satisfactory in arresting hemorrhage in epistaxis and in bleeding piles. It acts by stimulating the contraction and closure of the gaping vessel. It might be expected to fail when applied to vessels whose surroundings prevented contraction, as, for instance, in the indurated base of a gastric ulcer or perhaps in hemorrhage from bone.

Ergot is especially serviceable in postpartum hemorrhage. It stimulates contraction of the unstriped muscle of the uterus and thus compresses the veins and blood sinuses in the uterine wall. It also stimulates to contract the middle coat of the arteries and has been used in the treatment of hemoptysis. When administering ergot it must always be remembered that it causes peripheral vasoconstriction and so raises the blood pressure.

Local Treatment.—Arterial hemorrhage may be arrested spontaneously by the contraction of the vessel wall and the clotting of the blood. "If a small artery is completely divided, the circular fibers of the muscular coat contract and narrow the orifice; at the same time the internal and middle coats curl up in the interior of the vessel, and the longitudinal fibers contract and shorten it, so that it retracts within its sheath. As a result, there is clotting of blood; as soon as the blood comes in contact with the tissues that are injured, or which are not similar to the lining of the membrane of the vessels, it undergoes coagulation. Consequently, as soon as the blood escapes from the vessel, clotting tends to take place, unless the escape of blood be so free that the clot is swept away with it. The clotting within the vessel extends up to the nearest collateral branch." Later on, the clot becomes organized into fibrous tissue. If the vessel is only partially divided it cannot contract within its sheath and the hemorrhage is more apt to continue. The spontaneous arrest of hemorrhage from the veins and capillaries is due chiefly to clotting and sealing by lymph (Cheyne and Burghard).

Of all the artificial methods of arresting hemorrhage that by *ligature* is far and away the most important. The aseptic ligature is one of the great results of Lister's work. Of the absorbable ligatures catgut is the chief, and silk is the ideal non-absorbable ligature. Catgut may now be prepared in a manner that renders it aseptic and not too readily absorbed. It is certainly the best ligature to use in a field that is, or is likely to become, infected. Silk or linen thread have the great advantage of being easily prepared and may be used in aseptic tissues. It is better to use the smallest sizes of both catgut and silk that can be used with safety. It is no longer thought necessary to tie a ligature tightly enough to rupture the intima. If the walls of the vessel are brought firmly in contact, adhesions between them will take place and the vessel be quite safely occluded.

Suture of wounds in large arteries and veins may be successfully accomplished. Although Lambert of Newcastle successfully sutured a wound of the carotid artery in 1762, but little attention was given to this method of closing wounds of blood-vessels until recent years. This method of closure should be adopted in wounds of important vessels, such as the aorta, carotid, axillary, or femoral arteries, when not more than half the circumference of the vessel is divided and when the wound is aseptic. Experiments seem to show that if end to end anastomosis is performed, after complete division of the artery, complete occlusion will occur in a few weeks, but not until sufficient time has elapsed for the collateral circulation to become established. The endothelial and connective-tissue proliferation which closes the wound in a part of the vessel wall goes on to complete occlusion when the whole circumference has been divided and afterward stimulated by many needle punctures and by the presence of the suture material. Closure of wounds of veins by means of sutures has also been practised successfully. In the suturing only the outer coats should be included, the intima being avoided. The sheath of the artery should also be sutured.

Pressure is a valuable means of controlling capillary hemorrhage and that from small wounds and from veins. The hemorrhage from a ruptured varicose vein is thus readily stopped. Even bleeding from the sinuses of the brain may often be effectually arrested by pressure. In applying pressure it is important

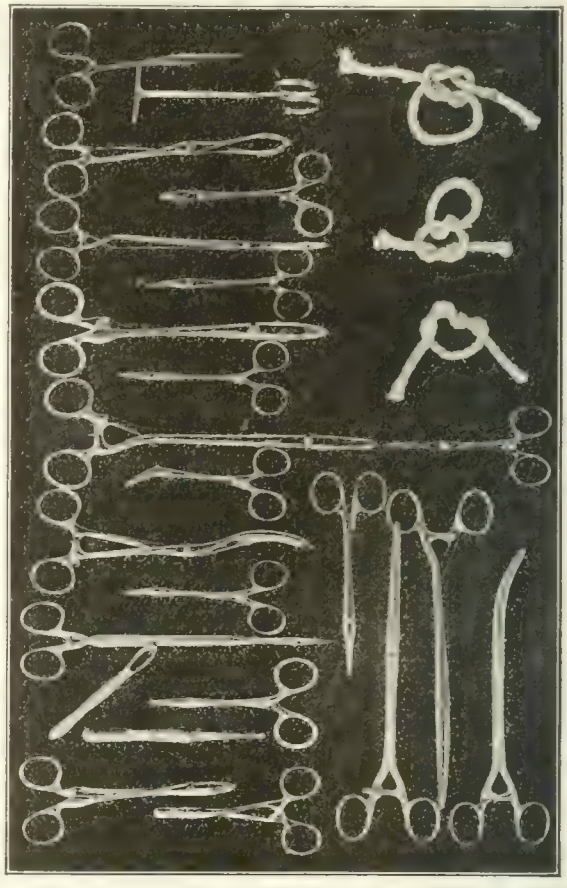


Fig. 3128.—Various Contrivances in Common Use for Arresting Hemorrhage. The three knots shown in the right-hand upper corner of the picture represent respectively (from above downward) the *surgeon's knot*, the *granny knot*, and the *reefer's knot*. Immediately below the last knot, placed transversely, is *Pean's artery forceps;* and below this are four different types of forceps known respectively (from left to right) as *Armstrong's forceps, Doyen's clamp forceps* (straight), *Terrier's clamp forceps* (curved), and *Richelot's clamp forceps* (lateral-curved). The left half of the picture is occupied by a series of eighteen different patterns of forceps known respectively (from above downward) as (1) *Kocher's forceps*, (2) *Pozzi's T-forceps*, (3) *Bottini's forceps*, (4) *Tait's forceps*, (5) *Pean's long light bleeding-point forceps*, (6) unnamed pattern of forceps, (7) *Greig Smith's heavy forceps*, (8) *Halsted's mosquito-point forceps*, (9) *Segond's bleeding-point forceps* (heavy), (10) *Horsley's lateral angular forceps*, (11) *angioclast*, (12) *Horsley's artery forceps* (curved on the flat,) (13) *Pean's long bleeding-point forceps*, (14) *Hamilton's artery forceps*, (15) *Horsley's artery forceps*, (16) *Esmarch's torsion forceps*, (17) *Greig Smith's small forceps*, (18) *Ferguson's artery forceps.*

to get the pad directly on the bleeding vessel. If this is at the bottom of a deep wound and it is not desirable to enlarge it, a graduated compress may be applied. Place first simply a small pad deep down on the bleeding point, then another against the first, and so on until sufficient pressure is obtained. In emergency cases, when bleeding takes place from an extremity, a bandage or handkerchief or a pair of suspenders may be placed around the limb above the bleeding point. This may be tightened by twisting as in the Spanish windlass.

Elevation of the limb is of material assistance. The pressure of the hemostatic forceps permanently stops the bleeding in many small cutaneous vessels. Doyen extended the application of this principle in his angiotribe.

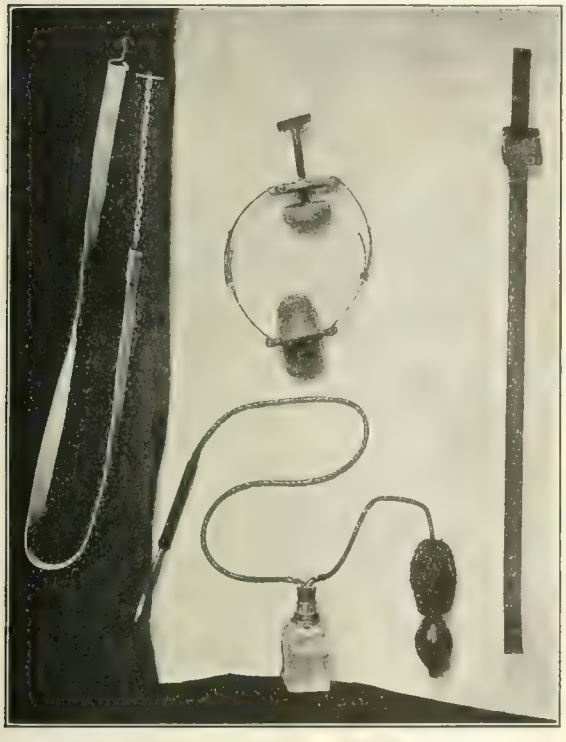


Fig. 3129.—Other Apparatus used in Arresting Hemorrhage. On the left-hand side, Esmarch's flat tourniquet; on the right, emergency tourniquet; in the center, above, Skey's arterial compressor; in the center, below, thermocautery apparatus.

Torsion has not been very extensively used. By torsion the intima and media are ruptured. They curl up, plug the lumen of the vessel, and are held by the twisted adventitia. If applied to large arteries the vessel should be caught, freed from its sheath and surrounding tissue and held by one pair of forceps at a point above where it is desired to rupture the inner coats. The cut end of the vessel is then caught by another forceps and twisted until the rupture is felt to occur. It can scarcely be called a safe method and should be confined to small and cutaneous vessels. In such cases it is unnecessary to apply more than one forceps and that to the cut end.

The *cautery* is still sometimes found useful as a hemostatic, particularly to arrest oozing from surfaces that are deep and inaccessible or where, because of the thinness of the tissue or its extreme friability, a ligature is contraindicated.

In certain cases of gastric hemorrhage, when the bleeding takes place from many small points or oozes from the surface of the mucosa, it may be arrested by brushing the surface over with a cautery at a dull red heat. No cautery is more effectual than the old actual cautery. The Paquelin thermocautery has been extensively used and many operating rooms are equipped with an electric cautery apparatus which is a very convenient form.

Hemorrhage from bone is sometimes troublesome. For the oozing from the edges of divided bone, Sir Victor Horsley has prepared an antiseptic wax. It is composed of beeswax 7 parts, almond oil 1 part, and salicylic acid 1 part. It is often very helpful. Suprarenal extract or adrenalin may be found the most satisfactory of all. The writer used it successfully in a case of secondary hemorrhage in acute osteomyelitis.

Cold, locally applied, in the form of Leiter's tubes, or cracked ice, may be used in robust patients, for the arrest of oozing. It acts by stimulating the muscular coats to contract and reflexly may stimulate vessels situated beneath the surface. Cold should generally be avoided in the weak and in acute anemia.

Heat, preferably in the form of hot saline solution, has a decidedly styptic action on tissues. The temperature should be 120° F. Heat applied in this way to oozing surfaces is sometimes very useful. If the solution is below 115° or 118° F. it may rather encourage than check hemorrhage.

Treatment of acute anemia resulting from hemorrhage is only second in importance to the arrest of the bleeding which caused it. Stimulants must be exhibited with caution until the bleeding is stopped, as their effect is often to increase intravascular pressure. They have an important place when used with discretion and good judgment. Opium is also valuable as an equalizer of the circulation and a determinant of blood to the cerebral centers.

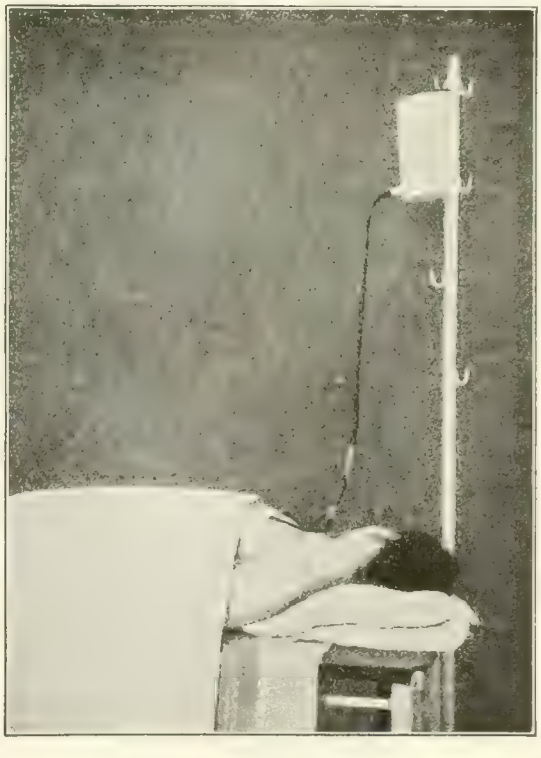


Fig. 3130.—Apparatus for Subcutaneous and Intravenous Injection of Saline Solution.

Transfusion.—In cases of severe hemorrhage the most important indication after the bleeding has been arrested is to refill the blood-vessels, and to raise

the intravascular pressure to a point compatible with life. This object is most quickly accomplished by the intravenous transfusion of physiological saline solution (six-tenths of one per cent.). It is readily prepared by adding one teaspoonful of common salt to a pint of water. The solution should be sterilized by boiling. Ten minims of adrenalin solution (1 to 1,000) may be added to further raise the blood pressure. The median basilic is generally used. After a compression bandage is applied to the arm the vein becomes prominent. It is exposed and a double ligature passed beneath it. The distal ligature is tied. A small incision is made in the wall of the vein with a pair of scissors or a knife, through which the point of the glass nozzle is passed into the vein. The proximal ligature is then tightened and the solution allowed to flow slowly into the vein. Precautions must be taken to prevent the entrance of air. One to three pints may be allowed to enter at a temperature of 105° F. When the nozzle is withdrawn the proximal ligature is tightened. Saline solution may be placed beneath the skin. Five pints will run through a needle into the subcutaneous below the axilla in half an hour. Indeed the subcutaneous injection of saline solution is very satisfactory although it does not enter the circulation as rapidly as when injected into the vein. Rectal salines given every four or six hours in quantities varying from four ounces to one pint, or given very slowly and continuously, are indicated when there is no emergency. In some cases, when there is no vomiting, considerable quantities may be given by mouth.

Direct transfusion from one human to another has been recommended for centuries, and this method is now advocated by Crile. Animal experiments show that the red cells may be disintegrated, the freed hemoglobin may then break down the white cells and set free sufficient fibrin ferment in the blood to cause intravascular clotting. Nevertheless, Crile speaks favorably of direct transfusion in both hemorrhage and shock. He advises the anastomosis of the radial with the median basilic or other veins. The transfusion may be allowed to continue for twenty minutes. The use of defibrinated blood has not proved successful. Transfusion of blood from another species, for instance the sheep, is not to be commended.

In extreme cases until the bleeding is stopped elastic bands may be applied to the extremities close up to the body, thus saving the patient's blood. The foot of the bed should be raised eight or ten inches, thus sending the major part of the blood toward the great centers of the nervous and circulatory systems. This is a most effective method of autotransfusion.

GEORGE E. ARMSTRONG.

Hemorrhoids.—See *Rectum and Anus, Diseases of the.*

Hemp.—See *Cannabis Sativa.*

Hemp, Canadian.—See *Apocynum.*

Hemp, Indian.—See *Cannabis Indica.*

Henbane.—See *Hyoscyamus.*

Henle, Friedrich Gustav Jacob.—Born of Jewish parents at Fürth, in Franconia, Germany, on July 19, 1809. He studied medicine at the universities of Bonn and Heidelberg, and received his doctor's degree in 1832. In 1840 he was appointed Professor of Anatomy in Zürich, Switzerland, and it was while he resided in that city that he published his famous work entitled "Allgemeine Anatomie," Leipzig, 1841. In 1844 he was called to Heidelberg, to fill the second Chair of Anatomy; and in 1849, when Tiedemann was made emeritus professor, Henle was promoted to the first Chair of Anatomy and to be the Director of the Anatomical Institute. Finally, in 1852, he was called to Göttingen, to fill the Chair of Anatomy which had been left vacant through the death of the elder Langenbeck. He continued to hold this professorship up to the time of his death, on May 13, 1885.

In his estimate of Henle's true place in the history of medicine, Pagel says that he ranks not only as one of the greatest anatomists, but also as one of the most prominent medical men of the nineteenth century. It was he, for example, who first discovered the cylindrical epithelium of the intestinal canal; who determined the limits of the different territories in the animal organism occupied by the various kinds of epithelium; who explained how the different epithelia were related the one to the other; who established the true relationship that existed between the central chyliferous vessels; who discovered the epithelium (endothelium) lining the

FIG. 3131.—Friedrich Gustav Jacob Henle.

blood-vessels; who demonstrated the loop-shaped renal canaliculi which bear his name ("Henle's loops"), etc. The great improvement which he effected in anatomical nomenclature deserves also to be mentioned here.

Of his published writings the following still remain to be mentioned: "Systematische Anatomie" (which was issued in two forms—a large edition, in 3 volumes, with the corresponding atlases, and a small compendium); and "Pathologische Untersuchungen," Berlin, 1840. There is reason to believe that it was from the ideas which Robert Koch found expressed in this book that he received the stimulus that prompted him to undertake his original bacteriological investigations into the etiology of tuberculosis, the infection of wounds, septicemia, anthrax, etc.

Henle was not only a successful teacher, an original investigator of the first rank, and an author of great merit; he also possessed personal characteristics that made him universally beloved. His pupils fairly idolized him. (This side of Henle's character is admirably brought out in the biography written by his son-in-law and successor—F. Merkel, Braunschweig, 1891.)

A. H. B.

Henna.—Under this name the leaves of *Lawsonia inermis* L. (fam. *Lythraceæ*) are extensively used in Eastern countries as a pigment for coloring the skin and hair and also as an astringent. Their use in jaundice is doubtless due to a superstition relating to their coloring matter. In this country they are enormously used as an ingredient of cigarettes. They contain a peculiar astringent resinous substance which has been called henotannic acid.

HENRY H. RUSBY.

Henoch, Eduard Heinrich.—A leading German authority in diseases of children. Born in Berlin,

Prussia, June 16, 1820. He pursued his medical studies chiefly under Schoenlein and Romberg in the University of his native city, and received his doctor's degree from that institution in 1843. In 1872 he was appointed Director of the Clinic and Policlinic for Children's Diseases in the Charité Hospital, and he served in this capacity up to the year 1893. It was he who first described, in 1874, the infectious disease of childhood since generally known as Henoch's purpura. His death occurred in 1900.

The titles of his most important published writings are the following: "Klinische Ergebnisse, gesammelt in dem königl. poliklinischen Institut der Universität," Berlin, 1846; "Klinik der Unterleibskrankheiten," Berlin, 3 volumes, 1852, 1854 and 1858 (3rd edition in 1863); and "Vorlesungen über Kinderkrankheiten," 1881 (10th edition in 1899). (Pagel.)

A. H. B.

Fig. 3132.—Eduard Heinrich Henoch.

Hepptine is the gastric juice of living, healthy, pigs. It is claimed for hepptine that in addition to its digestive properties it restores the tone of the stomach to its normal condition and tends to establish a normal gastric secretion. It is said to be indicated in dyspepsia and various gastric disorders, and to be contraindicated in hyperchlorhydria and gastric ulcer. The average dose is a tablespoonful in half a glass of water sipped during meal times.

R. J. E. Scott.

Heredity.—Heredity may be defined as a correlation between the variations of characteristics in individuals related to one another by birth.

The words used as the names of phenomena are apt to influence our conceptions of their character. This is particularly true of heredity. No doubt, most persons think of heredity as similar to the inheritance of goods and chattels. To them a son has received from his father the color of his eyes very much in the same way that he may expect to receive his seal ring or his watch. Such an idea is entirely foreign to the scientific conception of heredity, and in using the term it is necessary to keep in mind always its metaphorical character in order not to confuse the metaphor with the reality that it represents. Scientifically heredity is merely a special case of the correlation of variations.

This correlation may be *direct*, as between father or mother and son or daughter, between grandfather and grandson, etc.; or it may be *collateral*, as between brothers, sisters, brothers and sisters, uncles or aunts and nephews or nieces, between cousins, etc. In man and the higher animals inheritance is always *biparental*. That is to say, every individual has two parents; but there are cases in which there is only one parent, as in certain insects and crustacea that produce young most frequently by means of parthenogenetic eggs, and among some of the lower animals and the plants, which frequently produce new individuals by means of buds, underground shoots, etc. In such cases inheritance is *uniparental*.

Of direct inheritance there are three important types: (1) *blended* inheritance, where the child is intermediate in character between the two parents, as in stature; (2) *exclusive* inheritance, where the character of the child is like that of one parent but not like the other, if they differ, as in the color of the eyes; (3) *particulate* inheritance, where the characters of both parents appear in the child, but do not blend; for example, a pup may have spots, some of which are of the color of the mother, while others are like the coat of the sire, or a boy may have a nose like his father and eyes like his mother.

The subject of this article will be treated in two main divisions. The first will be a description of some of the principal phenomena of heredity, and second will be a discussion of the theories that have been advanced to explain the mechanism of inheritance.

I. The Phenomena of Heredity.

Our knowledge of the facts of heredity are derived by three methods of study, which may be designated as (*a*) observational, (*b*) statistical, and (*c*) analytical. The *observational method* was employed by the older breeders of animals and plants, and yielded many interesting facts, which were quoted extensively by Darwin in support of his theory of evolution. These observations were made, however, without regard to any good working hypothesis, and therefore failed to produce any general results of value.

The *statistical method*, founded by Galton, involves the orderly collection of a vast number of observations of the same kind and their integration by mathematical induction. This method has yielded important results in regard to racial heredity. The *analytical method*, founded by Mendel, is partially statistical but chiefly experimental. It depends on carefully planned matings of parents of known pedigree through a number of generations, and a statistical study of the offspring in each generation. It has yielded important results in regard to individual heredity and has contributed greatly toward an understanding of the mechanism of inheritance. These two methods (*b* and *c*) will be discussed below.

1. *The Statistical Method.*—The material for the statistical study of heredity is to be found in the variations and correlations among related groups of individuals, such as fathers and sons. Hence to avoid ambiguity, it will be necessary to treat briefly of the mathematical expressions for variability and correlation.

Variability.—Variation is deviation from the type, and for most statistical inquiries the type taken as the standard is the arithmetical mean of the population or group. Deviations are of two kinds, abnormal such as the "sports" of the horticulturist, and normal variations, which may be observed in every family or other group of individuals. The normal variations are found to be distributed about the mean in a way that may be expressed by certain mathematical formulæ derived from the theory of probability and chance (see articles, *Evolution* and *Variation*). The relations most frequently met with are represented in Fig. 3133.

The rectangles in this figure taken together form what is called a polygon of frequency, and the flowing curve is a theoretical curve of chance, or probability, that has been fitted to the polygon, which represents graphically the observed facts. Now if we plot the curves of two sets of observations, employing units of scale of the same value in both, the differences in the forms of the curves will depend upon the number

of individuals in the most frequent, or modal, class that is the tallest rectangle, and, supposing the curve to be symmetrical, upon the amount of *deviation* on either side of the mean. The amount of deviation that is the *variability* of the group, is measured by what is called the *standard deviation* (the "mean error" of the mathematicians). This is obtained by multiplying the square of the deviation from the mean of each class by its frequency, adding all the

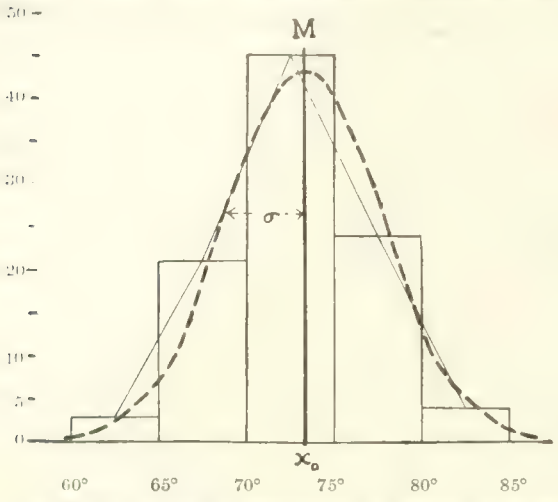


FIG. 3133.—Graphic Representation of a Series of Variations. Variation in the width of the angle at the apex of the shell in *Purpura lapillus*. $M x_o$, position of the mean; σ, standard deviation.

results together, dividing by the total number of observations, and finding the square root of the quotient, as indicated by the formula $\left(\sigma = \sqrt{\frac{\Sigma(x^2 f)}{n}}\right)$

The Greek letter σ is used as the symbol for this quantity. Its relation to the curve of frequency is shown at σ in Fig. 3133.

Correlation.—"Two variable organs are said to be correlated when the variation of one is accompanied on the average by more or less variation of the other, and in the same direction" (Galton, 1888). In order to determine the degree of *correlation* between two organs accurately, it is necessary to have a large number of observations and to arrange them in a "correlation table." There are several forms of correlation table, most of them constructed on the same principle, which is best illustrated, by one of the original, extended form, like Table I.

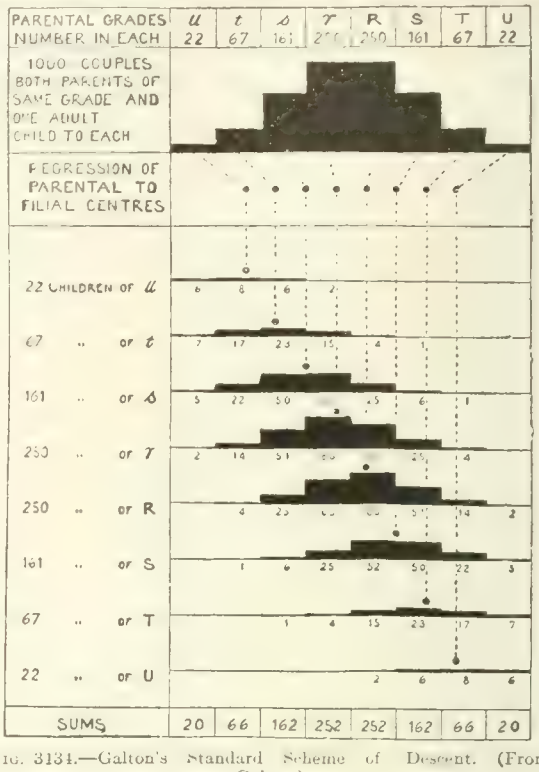


FIG. 3134.—Galton's Standard Scheme of Descent. (From Galton.)

The construction of this table may be understood from a consideration of the first column of entries. Five fingers of the right hand were found in which the length of the first joint was between 1.95 and 2 inches. These form a "*class*." Of the corresponding fingers on the left hand only one was of the same

TABLE I.—CORRELATION IN THE LENGTH OF FIRST JOINT OF INDEX FINGERS OF WOMEN, RIGHT AND LEFT HANDS. (From Whitely and Pearson.)

Left hand (relative Classes).	Right hand (subject classes).													Totals.
Length of joint in inches	1.95 to 2.00.	2.00 to 2.05.	2.05 to 2.10.	2.10 to 2.15.	2.15 to 2.20.	2.20 to 2.25.	2.25 to 2.30.	2.30 to 2.35.	2.35 to 2.40.	2.40 to 2.45.	2.45 to 2.50.	2.50 to 2.55.	2.55 to 2.60.	
1.90 to 1.95	1.0	1.0	1.0											3.0
1.95 to 2.00	1.0	2.0												3.0
2.00 to 2.05	1.5	7.5	13.0	4.0		4.0								27.0
2.05 to 2.10	1.5	2.5	12.0	17.0	3.5	1.0								37.5
2.10 to 2.15			3.5	21.0	32.0	7.0	1.0							64.5
2.15 to 2.20				4.5	38.75	35.5	9.75	1.5						90.0
2.20 to 2.25				1.5	7.25	45.25	45.25	5.25	0.5					105.0
2.25 to 2.30					1.0	8.25	30.5	28.5	2.25					76.5
2.30 to 2.35							7.0	41.25	24.5	3.25				76.0
2.35 to 2.40							1.0	5.5	17.75	13.5	0.25			38.0
2.40 to 2.45									3.5	12.0	6.5	0.5		22.5
2.45 to 2.50									1.0	2.75	1.75	0.5		6.0
2.50 to 2.55											1.0		0.5	1.5
2.55 to 2.60													0.5	0.5
Totals	5.0	13.0	29.5	48.0	82.5	98.0	100.5	82.0	49.5	31.5	9.5	1.0	1.0	551.0

length. One was shorter, 1.90 to 1.95 inches; and three were longer, one of these being exactly 2.05 inches long, was placed half in the relative class above and half below that mark. Thus the totals at the base of the columns show the number of fingers in each class of the right hand, while the figures in the columns show the number of associated fingers in each class of the left hand. The right hand is said to be the *subject* and the left hand the *relative* and each column is called an *array*. Conversely, we may, without altering the table, regard the left hand as subject, and the right hand as relative, and the arrays would then be the rows of figures, which are added up in the last column.

Now by this means we may study the correlation of any pair of organs in respect to any characteristic that permits of being expressed in quantitative terms. We may compare not only different organs or parts of the same individual, but also any suitable characteristics of distinct individuals, provided they are related in some constant way, as for example husbands and wives, fathers and sons, brothers and sisters, etc. But fathers and sons, and brothers and sisters are related by birth, and when we study the correlation between them we are studying what is called natural inheritance.

The Statistics of Heredity.—Some of the most important results of a long series of studies of inheritance are represented graphically in Galton's "Standard Scheme of Descent," which is reproduced in Fig. 3134. This scheme represents a supposed case in which there are a thousand couples of parents and in which each parent is mated to another of the opposite sex having relatively the same deviation from the mean in the character measured, and each couple is supposed to have one adult child. The parents are divided into eight classes having the relative frequency and deviation from the mean represented by the polygon of frequency at the top of the figure. The classes *R*, *S*, *T*, *U*, present positive deviations from the mean, and *r*, *s*, *t*, *u*, have corresponding negative deviations. The distributions of the variations in the children of each parental class are represented by the polygons below—drawn to the same scale. An attentive study of this diagram reveals many interesting things. In the first place the filial polygons are similar in form to the parental one. A dot above each filial polygon indicates the position of its mean; and the second point of interest is that the mean of any group of children does not correspond with the mean of its parents, nor with the mean of parents in general, but lies between the two. Still the mean of the children of *u* is much nearer the mean of *u* than is the mean of the children of *U*. There is evidently a correlation between the parents and their offspring. But this is not perfect, for, while parents with negative deviations from the mean have children whose deviations on the average are negative and those with positive deviations have children who deviate on the average in the positive direction, still in each case the mean of the children deviates from that of their parents and toward the mean of parents in general, which is probably the same as the mean of the population of which they form a sample. This tendency for the mean of the children to deviate from the type of their parents toward the type of the population in general is called *regression*. The results that follow from the laws of variability and regression in children are of considerable interest and importance. If we suppose parents of grade *U* to be especially gifted in some way, we see that when both parents are of this grade they may hope to have children equally gifted in the proportion of 6 to 22 or, say, two children equally gifted with themselves in a family of seven. On the other hand, if we take twenty children in grade *U*, only six will have parents as gifted as themselves, and two of them will be derived from very mediocre parents of grade *R*. Nevertheless, the chances that the exceptional parents will produce equally exceptional children as against mediocre children are 6 to 2, while the chances of mediocre parents of grade *R* are 2 to 154. The reason that there are so many gifted children of relatively mediocre parents is that there are so many mediocre parents. When we add up all the children in each grade, as is done at the bottom of the scheme, we find that the mean and variability of children in general is nearly the same as of parents in general. They would have been more nearly the same if we had taken larger numbers. So, if no selection is being made, the population as a whole in one generation will be the same in character as the previous one.

For the exact study of inheritance use is made of correlation, or regression, tables similar to Table I. We have converted Galton's scheme of descent into such a table (Fig. 3135) represented graphically by

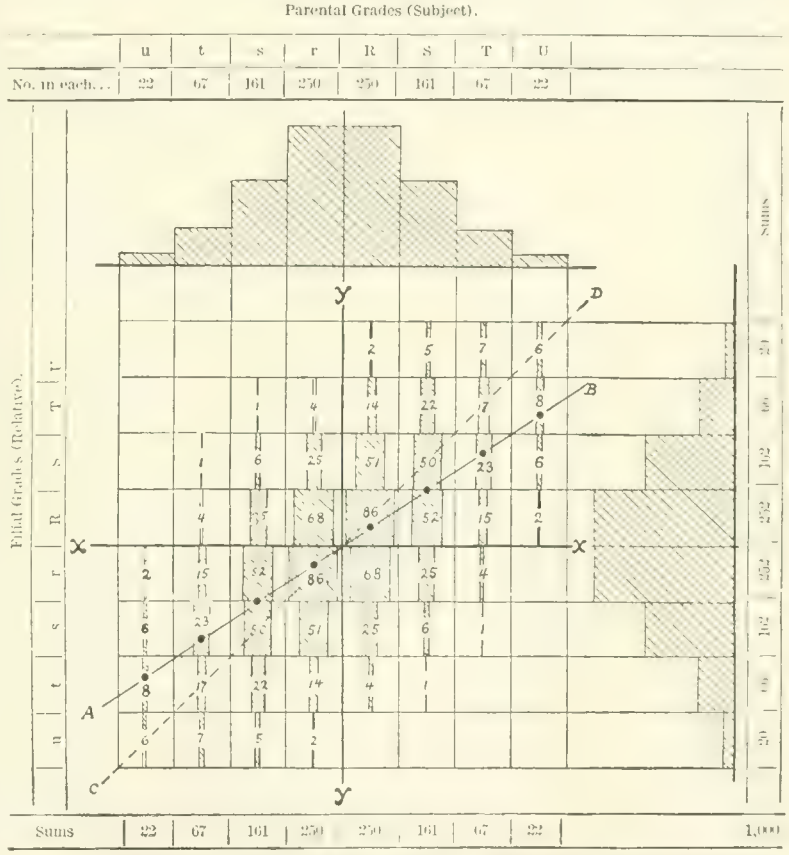


FIG. 3135.—Regression Table, Children on Parents. One thousand parents with mates of same grade and one adult child to each. (Data from Galton.)

placing each filial polygon as an array beneath the center of the corresponding parental grade, or class; and adding up the filial grades at the right. In this diagram the parental deviations are measured on the horizontal scale, and the filial deviations on the vertical scale. The heights of the shaded areas represent the frequency of each parental class, and widths represent frequency in the filial classes.

The line *YY* occupies the position of the parental mean and the line *XX* the position of the filial mean. The two lines cross at right angles in the middle of the diagram. The line *AB* is a straight line drawn through the position of the mean (represented by a round dot) in each array and through the point of intersection of the lines *XX* and *YY*. It is called the *regression line*. In an actual regression table it would not pass through every dot, but would be placed so that the deviations of the means above and below it would balance one another as nearly as possible. Now the slope of this line may be measured by taking the ratio between the distance of any point on the line *AB* from the line *XX* and the distance from the same point to the line *YY*. A point three spaces to the left or right of the line *YY* will be two spaces below or above *XX*. So the slope of *AB* may be said to be 2 in 3, or $\frac{2}{3}$. This quantity (in this case, $= \frac{2}{4}$) is called the *coefficient of regression*. It is the quantity which multiplied by the deviation of a parental class from the mean of parents will give the average deviation of its array of children from the mean of children. For example, parents of grade *S* deviate on the average one and one-half spaces of our scale from the mean of parents. $1\frac{1}{2} \times \frac{2}{3} = 1$, which is the deviation of the mean of the children of *S* from the mean of children in general. The slope of the regression line will differ in different cases. If there were no regression, the deviations of the parental class and of the array of offspring would be the same, and the regression line would occupy the position *CD*. On the other hand, if there should be complete regression, the mean of the filial array would be the same as the mean of children in general, no matter how great the deviation of their parents, and then the regression line would coincide with *XX*. The regression line, then, may lie anywhere between the position *CD* where the coefficient is 1 and *XX* where it is 0. So the less the regression the greater the coefficient, and *vice versa*. But it is evident that the slope of the line may depend on several factors. If we should plot the parental deviations on a scale having units twice as long as in the scale of filial deviations, the slope of the line would be reduced one-half. But having equal units of scales, we should find the same result if the variability of parents were twice that of children. Now differences of variability are found in the practical study of correlations and must be taken into account. This is done if we regard the slope of the regression line as the resultant of two factors: the ratio of the two variabilities, and an unknown factor that is called the *coefficient of correlation*.

Putting this into symbols, $r = \rho\frac{\sigma_2}{\sigma_1}$, where r = coefficient of regression, σ_1 = standard deviation of parents, σ_2 = standard deviation of children, and ρ = coefficient of correlation. From these considerations Pearson has derived a general formula* for calculating the value of ρ as follows:

$$\rho = \frac{\Sigma f x y}{n\sigma_1\sigma_2}$$

When there is perfect correlation $\rho = 1$; when there is no correlation $\rho = 0$. In the theoretical example that we have been studying parents and children are supposed to have the same variability, —that is, $\sigma_1 = \sigma_2$. In such a case, of course, $\rho = \rho\frac{\sigma_2}{\sigma_1}$, and the slope of the line *AB* represents the coefficient of correlation as well as that of regression.

This coefficient of correlation is taken as the statistical *measure* of *heredity*. In practice the coefficients of regression and correlation are found to be essentially the same in collateral inheritance; and also in direct inheritance, if we take into account only one parent of each couple and suppose the other to be chosen at random. The value of ρ calculated from observations in a number of such cases is given in Table II (see below).

TABLE. II.—(From Pearson.)

Relationship		Material.	Organs.		Coefficient of correlation ρ.
Subject.	Relative.		Subject.	Relative.	
Father	Son...	Middle class English	Stature	Forearm	0.369
Father	Son	Middle class English	Stature.....	Stature	0.396
Father	Daughter	Middle class English.....	Stature	Stature	0.360
Mother	Son.....	Middle class English.....	Stature	Stature	0.302
Mother.....	Daughter	Middle class English	Stature	Stature.....	0.284
Mother.....	Son	North American Indians	Head index.....	Head index.....	0.370
Brother	Daughter	North American Indians.....	Head index.....	Head index.....	0.300
Sire	Foal	Thoroughbred horses.....	Coat color.....	Coat color.....	0.517
Dam	Foal.....	Thoroughbred horses	Coat color	Coat color.....	0.527
Grandsire	Offspring	Thoroughbred horses	Coat color.....	Coat color.....	0.335
Grandsire	Offspring	Basset hounds	Coat color.....	Coat color.....	0.134
Brother	Brother	Middle class English.....	Stature.....	Stature	0.391
Brother	Brother	North American Indians	Head index	Head index	0.379
Colt	Colt	Thoroughbred horses	Coat color.....	Coat color.....	0.623
Sister	Sister	Middle class English.....	Stature.....	Stature	0.444
Sister	Sister	North American Indians.....	Head index.....	Head index	0.489
Filly	Filly	Thoroughbred horses	Coat color.....	Coat color.....	0.693
Brother	Sister	Middle class English.....	Stature	Stature	0.375
Mother	Sister	North American Indians	Head index	Head index	0.340
Colt.....	Filly.	Thoroughbred horses	Coat color.....	Coat color.....	0.583
Whole brethren	Whole brethren....	Basset hounds	Coat color.....	Coat color	0.508

The Mid-parent.—But in man and the higher animals inheritance is always biparental, and in order

* In this formula x and y are the deviations from their means of the two organs of an associated pair, as father and son, f is their frequency, n is the total number of pairs, and Σ is the symbol for addition.

When there is no correlation $\Sigma(x\,y\,f) = 0 \therefore \rho = 0$.

When correlation is perfect $y = x$ and $\sigma_2 = \sigma_1$.

Then $\frac{\Sigma(x.y.f)}{n} = \frac{\Sigma(x^2 f)}{n} = \sigma_2$ and $\frac{1}{\sigma_1\sigma_2} = \frac{1}{\sigma^2}$

$$\frac{\Sigma(x.y.f)}{n\,\sigma_1\sigma_2} = \frac{\sigma^2}{\sigma^2} = 1 = \rho.$$

to study the true relations between parents and offspring it is necessary to take both parents into account. This involves the correlation of three variable quantities. In order to avoid this difficulty the two parents are combined into a single artificial individual called the *mid-parent*. For example, Galton found that the mean stature of women in England is to the mean stature of men as 1 : 1.08. So in order to study the inheritance of stature, he converted the stature of each mother and daughter into its "male equivalent" by multiplying it by 1.08; and he obtained the mid-parent by taking the mean of the father's stature plus the mother's male equivalent. Thus if the father had a stature of seventy inches and the mother of sixty-six inches, the stature of the mid-parent would be

$$\frac{70 + (1.08 \times 66)}{2} = 70.64$$

In the study of heredity, however, deviations from the mean are used more frequently than the absolute dimensions of organs. Therefore Pearson has generalized and simplified Galton's formula for the mid-parent by putting it in this form:

$$\tfrac{1}{2}\left(h_1 + \frac{\sigma_1}{\sigma_2} h_2\right) = \mathrm{H}$$

where h_1 = the deviation in the particular father from fathers in general; h_2 = deviation of mother mated to this father from the type of mothers, σ_1 = standard deviation of fathers in general; σ_2 = standard deviation of mothers, and H = deviation of the mid-parent from the type of mid-parents. This formula will apply to measurements of any organs, and it enables one to calculate easily either the deviation or the absolute value of the organ in the mid-parent. Having calculated the mid-parents, one may study the correlation between children and mid-parents, just as if the latter were single individuals.

The Law of Ancestral Heredity.—Now we are prepared to consider the influence of each ancestor upon the characteristics of the child. Returning to Fig. 3135, if there were no inheritance, the means of all the arrays would lie along the line *XX;* and we may think of heredity as a force* tending to pull each array away from *XX* in the direction of its parental grade, that is, toward the line *CD*. Now the question is, How much of this pull is exerted by each parent, grandparent, great-grandparent, etc.?

From the study of a variety of data, Galton came to the conclusion that, of the total heritage, the mid-parent contributes one-half, the mid-grandparent one-quarter, the mid-great-grandparent one-eighth, and so on. Or, if h be the mean deviation of a given group of offspring from offspring in general and H_1, H_2, H_3, etc., be the deviations from their mid-parental means of the mid-parent, mid-grandparent, etc., of these offspring, then

$$h = \tfrac{1}{2}\,\mathrm{H}_1 + \tfrac{1}{4}\,\mathrm{H}_2 + \tfrac{1}{8}\,\mathrm{H}_3 \ldots \text{etc.}$$

If the mid-parent contributes one-half, each parent will contribute one-quarter. So we may state Galton's law in the words of Pearson as follows:

"Each parent contributes on an average one-quarter, or $(0.5)^2$, each grandparent one-sixteenth, or $(0.5)^4$, and so on, and that generally the occupier of each ancestral place in the nth degree, whatever be the value of n, contributes $(0.5)^{2n}$ of the heritage."

Galton's series, $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} \ldots$ etc. = 1, is a geometrical series having a total of one. But the values $\frac{1}{2}$, $\frac{1}{4}$, etc., may not be true for all species, and Pearson, therefore, proposes to substitute the symbols γa, γa^2, γa^3, etc., in which there are two factors, one constant in each generation (γ), and one which varies in a geometrical series (a, a^2, a^3, . . . etc.). Galton's law would now take the form

$$h = \gamma(a\mathrm{H}_1 + a^2\mathrm{H}_2 + a^3\mathrm{H}_3 \ldots \text{etc.}).$$

* Note that this is a purely metaphorical expression.

Now when $\gamma(a + a^2 + a^3 \ldots \text{etc.}) = 1$,

$$\gamma a \quad 1 - a \quad 1 \quad 1 \quad 1$$
$$1 - a \;\; \therefore \gamma = \frac{}{a} = \frac{}{a} - 1 \;\; \therefore a = \frac{}{1 + \gamma}$$

So we may eliminate the quantity a from the formula by substituting this value and our formula becomes:

$$h = \gamma\left(\frac{1}{1+\gamma}\mathrm{H}_1 + \frac{1}{(1+\gamma)^2}\mathrm{H}_2 + \frac{1}{(1+\gamma)^3}\mathrm{H}^3 \ldots \text{etc.}\right)$$

But if we wish to be very exact, we must take into account the fact that the variability of all the offspring, σ, may differ from the variability of the successive generations of mid-parents, σ_1, σ_2, σ_3, etc., so the ratios of these standard deviations must be included in our formula, which then becomes:

$$h = \gamma\left(\frac{1}{1+\gamma}\cdot\frac{\sigma}{\sigma_1}\cdot\mathrm{H}_1 + \frac{1}{(1+\gamma)^2}\cdot\frac{\sigma_1}{\sigma_2}\cdot\mathrm{H}_2 + \frac{1}{(1+\gamma)^3}\cdot\frac{\sigma}{\sigma_3}\cdot\mathrm{H}_3 \ldots \text{etc.}\right).$$

This is the *law of ancestral heredity* as given by Pearson in its complete form. It is undoubtedly a generalization of great importance, expressing the statistical results obtained by a study of blended inheritance. According to this theory the degree of correlation between parents and offspring will depend upon the hereditary influence represented by the symbol γ. In Galton's original formula $\gamma = 1$, very nearly. The effects of different values of γ are shown in the following table:

TABLE III.—HEREDITY—DIRECT LINE. (From Pearson.)

Offspring and—	Coefficient of Correlation, ρ. When $\gamma = 1$.	When $\gamma = 0.9$.	When $\gamma = 2.35$
Parent	0.3000	0.2851	0.4000
Grandparent	0.1500	0.1425	0.2000
Great-grandparent	0.0750	0.0713	0.1000
Great-great-grandparent	0.0375	0.0356	0.0500
nth order grandparent	$0.6 \times (\frac{1}{2})^n$	$0.5702 \times \frac{1}{2}^n$	$0.8 \times (\frac{1}{2})^n$.

These theoretical values of the coefficient of correlation should be compared with the values obtained from observation in Table II. From the study of "a really considerable amount of quantitative measurements of heredity" Pearson concludes that the values of the coefficient of heredity given in the first column of Table III (when $\gamma = 1$) "seem to fit the observed facts fairly well in the case of *blended* inheritance."

Table II gives cases also of collateral inheritance, and the theoretical values, when $\gamma = 1$, are given below:

TABLE IV.—COLLATERAL HEREDITY. (From Pearson.)

Relatives.	Correlation when $\gamma = 1$.
Brothers	0.4000
Uncle and nephew	0.1500
Great-uncle and nephew	0.0625
First cousins	0.0750
First cousins, once removed	0.0344
Second cousins	0.0172
Second cousins, once removed	0.0082
Third cousins	0.0041

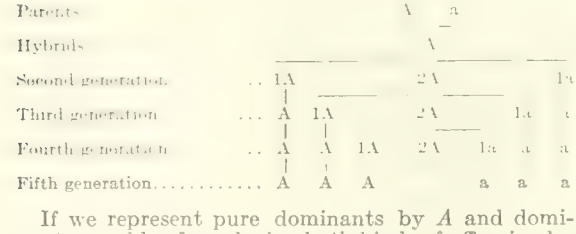
We see that brothers are more closely related than parent and offspring, and the correlation between first cousins is the same as that between offspring and great-grandparent.

2. *The Analytical Method.*—The phenomena formerly classified as exclusive and particulate inheritance, prepotency, and the like, are best treated by the analytical method, and are usually included in the term *Mendelian inheritance*, or Mendelism.

When individuals of separate races or species are crossed, the mongrel or hybrid offspring of the first generation may be more or less intermediate in character between the two parents, or they may resemble one parent only in some respects. But in subsequent generations there is greater diversity among the offspring, and reversion to one or the other parental type is common. The facts were noted by Darwin, but the first one to study them by statistical methods was Gregor Mendel, abbot of Brünn in Moravia. Mendel's work was published in 1866 and 1870, but it remained practically unnoticed until 1900, whe De Vries, happening to find a reference to it, looked it up and was surprised to discover that Mendel had anticipated results which De Vries himself was then about to publish. Mendel worked with varieties of garden peas, *Pisum sativum*, and studied one character at a time, first testing the varieties to make sure that they would breed true. He found that when the parents possessed certain contrasted characters one character of each pair would fail to appear in the first generation of offspring, but would reappear in subsequent generations. He called the character that appears exclusively in the first generation *dominant*, while the one that reappears only in later generations he termed *recessive*. In peas he found that the rounded form of the seed is dominant and the wrinkled form recessive, the yellow color of the cotyledons of the ripe seed is dominant, the green color recessive, and the same is true of a number of alternative characteristics. Now the point of Mendel's work is that he found the dominant and recessive characters to reappear in succeeding generations according to a definite and simple numerical law.

If a certain dominant character be represented by *A* and the corresponding recessive by *a*, then all the offspring of the first generation will have apparently only the character *A*. But if the flowers of this generation are fertilized with their own pollen, the next generation will contain 1*a* to 3*A*. These plants being again self-fertilized, all of the recessives, *a*, are found to breed true and to continue to do so during succeeding generations. One-third of the dominants also breed true in the same way, but the other two-thirds give rise to both forms, as the hybrids did, in the same proportion of one to three.

These relations may be represented by the following diagram:



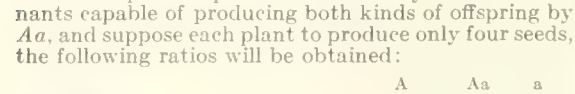
If we represent pure dominants by *A* and dominants capable of producing both kinds of offspring by *Aa*, and suppose each plant to produce only four seeds, the following ratios will be obtained:

	A		Aa		a
Second generation	1	:	2	:	1
Third generation	3		2		3
Fourth generation	7	:	2	:	7
Fifth generation	15		2		15
Sixth generation	31		2		31
$1 + n$th generation	$2^n - 1$		2		$2^n - 1$

If we consider two or more characters at a time, the results become correspondingly complicated, for characters that are not mutually exclusive may appear in the offspring in any possible combination. Thus the seed may be dominant in shape and recessive in color, or *vice versa*, or it may be dominant in both or recessive in both. With each of these combinations may be associated inflated or constricted pods, long or short stems, and other alternative characters. In the peas Mendel found in all seven pairs of alternative characters. When one pair only is considered and a pure dominant is crossed with a recessive two out of four of the second generation of offspring will breed true, half of these being dominants and half recessive. When there are two pairs of characters four out of sixteen offspring in the second generation will breed true, of these constant combinations one will be dominant in both characters, one recessive in both, and two dominant in one and recessive in the other. As all of these combinations may appear in the offspring of a single plant of the first generation, Mendel inferred that in the ovaries and anthers of plants of the first generation there are formed as many kinds of germ-cells as there are possible constant combinations of characters, and that they are formed in equal numbers. This led to the theory of *segregation*.

Terminology.—What is to follow will be clearer if before proceeding we define some of the terms that have arisen in connection with the recent study of Mendelian inheritance, for most of which we are indebted to Bateson. The offspring resulting from an initial mating are known collectively as the *first filial* generation, represented by the symbol, F_1. Their offspring are the *second filial generation*, F_2; and they in turn may produce F_3, etc. The germ-cells, whether eggs, pollen-cells or spermatozoa are called *gametes*. The individual produced by the union of two gametes is a *zygote*. That something, whether material or otherwise, which when present in the gamete determines a certain character in the resulting zygote, is called the *factor*, or *gene*, for that character. When two contrasting characters form an alternative pair, they are said to be *allelomorphic*, and are described as a pair of *allelomorphs*. The visible, or *somatic*, characters forming such a pair are called *unit-characters*. The term *phenotype* is used to designate all the individuals bearing the same characters.

Segregation.—Mendel's greatest contribution to science is the theory of segregation. According to this theory the facts of alternative inheritance can be explained by the supposition that the two factors for a pair of allelomorphs are never present together in the same gamete, and that when gametes containing factors for each character of an allelomorphic pair are produced by one parent, they are produced in equal numbers. For example if a pure bred black guinea-pig be mated with a white one. The F_1 generation will all be black, but when these individuals are bred together, the resulting F_2 generation consists of both black (*B*) and white (*b*) animals in the proportion $3B : 1b$. This is what would be expected if the gametes of F_1 are of two kinds, half containing the factor *B* and the other half *b*. If fertilization is a matter of chance, the probable combination of factors in F_2 may be represented thus:



That is to say, with two kinds of gametes in equal numbers uniting at random the probable *gametic constitution* of the zygotes would be represented by the formula

$$BB + 2\,Bb + bb.$$

But because black is dominant in this case over white, all individuals containing the factor *B* will have black coats. Therefore the visible, or *somatic*, characters of the offspring will be represented by the formula, $3B + 1b$. This is the fundamental *Mendelian ratio*, three to one. When these black guinea-pigs of the F_2 generation are tested by breeding, they are found to be of two kinds. On the theory of segregation one-third of them will contain only factors for

the dominant character and will breed true, while two-thirds will contain the factors for both characters, and when bred together will produce both kinds of offspring in the proportion of three to one. Breeding experiments on a large number of animals and plants have given results which are in general accord with this theory.

Dominance.—While dominance was the first recognized and most striking feature of medelian inheritance, it is not an essential feature, as segregation is. Cases are on record in which offspring are produced in a Mendelian ratio and yet the heterozygotes are intermediate in character between the two parental forms. Among plants Correns (1905) found that when a certain strain of *Mirabilis jalapa* with white flowers is crossed with a pink variety the F_1 generation has light pink flowers. When these are self-fertilized the resulting F_2 generation are white, light pink, and pink in the proportion 1 : 2 : 1.

Among birds a similar example is afforded by the Andalusian breed of fowls. The chief characteristic of this breed is a slaty blue color (Punnett, 1911) really due to a fine mosaic of black with white (Castle, 1911). Fanciers have never been able to make these fowls breed true. When the blue fowls are mated a large number of the offspring are either black or white splashed with gray. Bateson and Punnett found that the proportion is one black + two blue + one white, and that when white and black are mated all the chicks are blue. Evidently the unit-characters are black and white and the blue fowls are heterozygotes.

In many cases of dominance, the dominant character is positive while the recessive character is negative. In both plants and animals whiteness is recessive to color, the silky plumage of fowls, which lacks barbules, is recessive to ordinary plumage, tallness in peas is dominant over shortness, etc. These facts may have suggested to Bateson an important modification that he has introduced into the Mendelian theory, this is the hypothesis of *presence and absence.*

According to this hypothesis "a dominant character is the condition due to the *presence* of a definite factor, while the corresponding recessive owes its condition to the *absence* of the same factor." Thus a green pea owes its recessive greenness to the absence of a factor which, if present, would cause the chlorophyll to turn yellow. The original theory required a separate factor for each character in an allelomorphic pair, as one for green and one for yellow. But difficulties were presented by certain complex ratios, to be discussed in a later section, and it was to meet these difficulties that the presence and absence hypothesis was invented.

Experimental Tests.—The question whether a given character in any race is dominant or recessive can not be determined by inspection, and usually homozygous dominants and heterozygotes are indistinguishable to the eye. To determine the gametic constitution of an individual, even of known pedigree, it may be necessary to make a breeding experiment. In plants the test for purity of constitution is generally most easily made by self-fertilization. If the plant is homozygous it will breed true, if heterozygous the recessive character will appear in one-fourth of the offspring.

With animals the test is usually made by a back cross on to the parental stock. Suppose it is required to test a pair of guinea-pigs, one black and one white (with pink eyes). Representing the factor for black by *B* and its absence, white, by *b*, the results of two matings would be:

P_1 ..... $(BB) \times (bb)$

F_1 .. $n(Bb)$

F_2 ..... $n(BB) + 2n(Bb) + n(bb)$

If F_1 is all black and F_2 is three black to one white, we know that the parents (P_1) are homozygous and that F_1 is all heterozygous. Then one of the "extracted" whites of F_2 may be expected to prove itself homozygous by giving all white offspring when mated with the white member of the first pair, or half white and half black if mated with one of F_1. The gametic combinations in the latter case are shown in the following table:

Gametes	Heterozygous Black F_1: *B*	*b*
White F_1: *b*	*Bb*	*bb*
b	*Bb*	*bb*

Offspring. 1 *Bb* : 1 *bb*

The black guinea-pigs in F_2 will be either homozygous (*BB*) or heterozygous (*Bb*). To discover the number of each form present in this generation it is necessary to test each individual by breeding. This may be done by mating with the original white stock P_1 or with one of the extracted whites. If the individual is heterozygous, the offspring will be black and white in equal numbers, as shown in the table below:

Gametes	Heterozygous black F_2: *B*	*b*
Extracted White F_2: *b*	*Bb*	*bb*
b	*Bb*	*bb*

Offspring — 1 *Bb* 1 *bb*

If the black guinea-pig to be tested is homozygous and is mated as before, the result will be all blacks as as follows:

Gametes	Homozygous black F_2: *B*	*B*
Extracted White F_2: *b*	*Bb*	*Bb*
b	*Bb*	*Bb*

Offspring — All *Bb*, heterozygous black.

These are the expected results in testing any pair of alternative unit-characters.

Variability of the Ratios.—So far we have treated the Mendelian ratios as if they were invariable, but in practice this is far from true. It is very seldom that the results of any series of matings accord exactly with expectation. Some examples are given in the following table:

Authority and material.	Matings.	Number of offspring	Dominant.	Recessive.	Expectation
Mendel, 1866, Peas	Hybrids round self-fertilized	7324	5474	1850	5493 : 1831
	Hybrids high, self-fertilized	1064	787	277	798 : 266
Castle, 1905, Guinea-pigs	Hybrid pigmented inbred	223	158	65	167 : 56
	Hybrid pigmented × albino	284	148	136	142 : 142
Davenport 1908, Canaries	Heterozygous crested inbred	66	48	18	49.5 : 16.5

Deviations from expectation may result from (*a*) the chances of random fertilization, (*b*) selective fertilization, (*c*) differential mortality, (*d*) blending of characters, (*e*) the presence of unrecognized unit-

characters, and (f) from errors of observation. If the conditions of an experiment are such that a simple Mendelian ratio may properly be expected, then the deviations from the expected results should not exceed a number that may be determined by the mathematical laws of chance. In statistical theory this comes under the rule for "simple sampling of attributes" (Yule, 1911), and the agreement between observed results and expectation is measured by the standard deviation of simple sampling, also called the *standard error* of the number of successes. If in a series of matings n be the total number of offspring; p, the expected proportion showing the dominant; and q, the expected proportion showing the recessive character of a pair of allelomorphs, then the standard error of the number of dominants or recessives will be

$$\sigma = \sqrt{pqn},$$

and if the observed deviation from expectation is not greater than three times the standard error it may safely be attributed to the chances of fertilization.

To illustrate this method of testing an observed ratio, take Castle's case of the hybrid pigmented guinea-pigs which were bred together. The expectation was that three-fourths of the young would be pigmented and one-fourth albinos. The number of young born was 223. Then the standard error will be given by the equation

$$\sigma = \sqrt{0.75 \times 0.25 \times 223} = 6.47$$

The number of albinos produced was 65, nine more than expected. But as 9 is less than twice the standard error, it may be safely inferred that this deviation is due to chance, and not to any disturbing factor.

If instead of comparing the absolute numbers with expectation, it is desired to test the observed ratio of dominants or recessives, then we use the standard error of the *proportion* of successes,

$$s = \sqrt{pq\frac{1}{n}}$$

For example East and Hayes (1911) in their study of inheritance in maize obtained by crossing a non-starchy with a starchy dent variety an ear of corn (No. 19 × 7 − 2) containing 371 grains in the following proportions:

Total	Starchy	Non-starchy	Ratio	Deviation
371	297	74	3.2020:0.7980	0.2020

The expected ratio was 3:1, therefore

$$s = \sqrt{0.75 \times 0.25 \times \frac{1}{371}} = 0.0225$$

The observed ratio deviates from expectation by nearly ten times the standard error, and we may infer therefore that in this case the proportion has been influenced by some other factor than the chances of fertilization.

If the results of matings are expressed as a percentage instead of a ratio, the standard error of the percentage is given by the formula

$$s = 100\sqrt{pq\frac{1}{n}}$$

It has been pointed out by Yule (1911) that the standard error is the most convenient and best measure of the accordance between observed results and expectation. More commonly, however, the so-called *probable error* is used. This is obtained by multiplying the standard error by 0.6745,

$$E = 0.6745\sigma$$

This quantity preceded by the sign ± is often written after the observed quantity. Thus in the last example the ratio is

$$3.2020:0.7980 \pm 0.01517,$$

which means that it is an even chance that the true ratio does not differ from the one observed by more than 0.01517. East and Hayes compare their deviations with a quantity ("PE") which is four times the probable error. This is apt to be misleading, and is justified only by the fact that a deviation which does not exceed four times the probable error may be due to the chances of sampling.

Complex Ratios.—When crossing occurs between parents that differ in two or more pairs of allelomorphs the ratios become complex, Mendel, for example, in his experiments on peas, fertilized a plant bearing round yellow seeds with pollen from one having wrinkled green seeds. All the seeds of the F_1 generation were round and yellow. From these 15 plants were raised, and being self-fertilized, produced 556 seeds (F_2). These were 315 round yellow, 101 wrinkled yellow, 108 round green, and 32 wrinkled green, approximately in the ratio 9:3:3:1. The following diagram shows how the union of parents heterozygous in two pairs of unit-characters will produce this ratio.

Gametes	*YR*	*Yr*	*yR*	*yr*
YR	*YR* *YR*	*YR* *Yr*	*YR* *yR*	*YR* *yr*
Yr	*YR* *Yr*	*Yr* *Yr*	*Yr* *yR*	*Yr* *yr*
yR	*YR* *yR*	*Yr* *yR*	*yR* *yR*	*yR* *yr*
yr	*YR* *yr*	*Yr* *yr*	*yR* *yr*	*yr* *yr*

In this diagram the capital letters represent the factors for the dominant characters, yellow and round, and the small letters indicate their absence, or the presence of the corresponding recessive characters, green and wrinkled. In the sixteen squares representing the zygotes, nine contain both *Y* and *R*, three contain *Y* only, three *R* only, and one is purely recessive (*yr*), and the ratio of visible somatic characters is therefore $9YR:3Yr:3yR:1yr$.

The same ratio, 9:3:3:1 is obtained in the F_2 generation from a cross between a dark short-haired and an albino long-haired guinea-pig (Castle, 1911) and this is the normal ratio when two independent pairs of unit characters are concerned. With three pairs of characters, there are eight terms in the ratio. In general, if n be the number of allelomorphic pairs, the number of phenotypes and their ratios in the F_2 generation will be given by expansion of the expression $(3 + 1)^n$.

Latent Characters.—If a black animal be mated with an albino, the offspring will all be black, or both black and white. Brown mice bred together produce only brown or brown and white. Therefore the union of a brown mouse with an albino would be expected to give similar results. But experiments have shown that in mice there are at least four kinds of albinos (Castle, 1911), which with a brown mate produce gray, black, cinnamon, and brown young respectively. As it may be shown that the factors for gray, black, and cinnamon are absent in brown mice, it is inferred that when these colors appear in the young they are supplied by the albino parent, in which they are supposed to exist in a *latent* condition. This latency has been explained as due to the absence of a color factor, usually represented by the symbol *C*, which is present in all pigmented animals. In the brown mouse the factors *C* and *Br* occur together and cause the appearence of brown pigments, whereas in the albino the various factors for pigments may be present but are unable to produce any visible effect in the absence of *C*.

Epistacy.—The offspring resulting from a mating between a pure bred pigmented and an albino guinea-

pig are all pigmented of the color of the pigmented parent. But when a pure bred black guinea-pig is mated with a red one all the young are usually black with a slight reddish tinge. This is not a case of presence and absence, for the red pigments is formed but is masked by the more opaque black pigment. To distinguish this form of dominance from that met with when a pair of truly allelomorphic characters are brought together in the same individual, Bateson invented the terms *epistatic* and *hypostatic*. In our example black is epistatic to red, which is hypostatic in the presence of black.

Distributive Factors.—The color of animals is not always distributed evenly over the body. It may be confined to certain parts of each hair, or the hairs is some regions of the body may differ more or less from the hairs in other regions, producing patterns of various kinds. Study of the inheritance of pattern has resulted in the discovery of a number of *distributive factors*.

Of particular interest is the factor *A*, which produces the agouti, or gray, color common in wild animals, such as wild mice, rabbits and guinea-pigs. In this type of coloration there is a reddish-yellow band of pigment on each hair near the tip, while the rest of the hair is black.

Castle obtained agouti guinea-pigs by breeding certain red guinea-pigs with black ones. The F_1 agouti individuals when bred together produced young (F_2) of three kinds, agouti, black, and red in the proportion of 9 : 3 : 4. This appears to be a new Mendelian ratio, but that it is in reality merely a modification of the familiar 9 : 3 : 3 : 1, will be seen from the following diagram:

		Black		Red
		B_2	×	R_2A_2
	F_1	*BRA*		(agouti)

Gametes	*BA*	*B*	*RA*	*R*
BA	B_2A_2 agouti	B_2A agouti	BRA_2 agouti	*BRA* agouti
B	B_2A agouti	B_2 black	*BRA* agouti	*BR* black
RA	BRA_2 agouti	*BRA* agouti	R_2A_2 red	R_2A red
R	*BRA* agouti	*BR* black	R_2A red	R_2 red

F_2

If we assume in this case that the agouti factor, *A*, is latent in the red parents, the gametic formula for F_1, will be *BRA* (omitting symbols for absence and indicating the homozygous condition by the subscript "2"), and the gametes produced by F_1, will be of four kinds, *BA*, *B*, *RA*, and *R*. Inbreeding will give the results shown in the diagram, which indicates the sixteen possible combinations of factors and the resulting coat color in the F_2 generation. In nine of the squares *B* and *A* come together and the proportion of agouti individuals was nine in sixteen. *B* occurs without *A* three times and we have three black. In four squares is *R* without *B* and we have four red guinea-pigs, but three of them contain the agouti factor, *A*, in a latent condition, and one is a pure homozygous red. These inferences have been tested and confirmed by Castle (1913) in an extensive series of experiments.

Further treatment of the distributive factors would expand this article beyond permissible limits. To obtain a conception of the complexity of the subject the reader should consult Little's beautifully illustrated treatise (1913). A useful general treatment of this subject with a discussion of various complex Mendelian ratios is given by Plate (1913, p. 112 *et seq.*).

Compound Characters. Besides the agouti color, there are various other colors and patterns that may be regarded as the product of the combined effect of one or more factors for pigments and one or several distributive factors. To such characters produced by the interaction of several factors Bateson gave the name *compound characters*. They are not confined to color. An example of a structural character of this kind is the walnut comb characteristic of Malay fowls (Fig. 3136). Other kinds of combs are rose, pea, and single, the latter is recessive to the other two. When rose is crossed with pea the F_1 generation all have walnut combs, as was discovered by Bateson, who obtained by inbreeding these birds an F_2 generation with four kinds of combs walnut, rose, pea, and single in the proportion 9:3:3:1. The single comb proved to be a pure recessive, and the walnut comb is believed to be produced by the interaction of the two dominant factors for rose and pea comb. It was this case that led to the development of the presence and absence hypothesis.

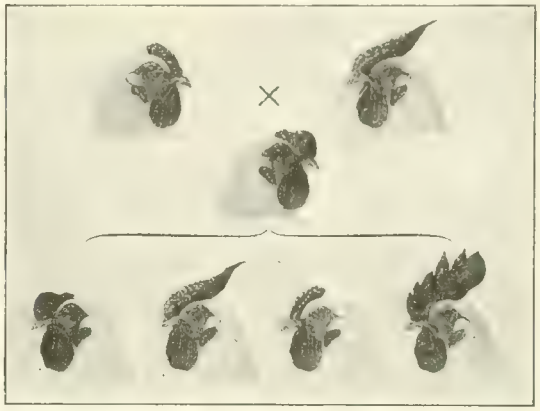


Fig. 3136.—Effects of Crossing Pea Comb with Rose Comb. In F_2 (bottom row) are found walnut, pea, rose, and single. (From Baur and Goldschmidt's Wandtafeln.)

Linkage.—Hitherto we have dealt with characters that are inherited independently. But there are some characters that are associated in inheritance. Mendel found in peas violet-red flowers associated with gray-brown seed coats, and white flowers with white seed coats. In sweet peas there has been found in certain strains a linkage, or coupling, of gametic factors for color with the hooded character of the standard, and of color of flowers with shape of the pollen.

In animals we have many familiar examples, as the beard of man, antlers of the stag, brilliant colors and special ornaments in birds, that are limited to the male sex, although they may be transmitted through the mother. Besides these secondary sexual characters, Morgan (1913) has found in insects certain characteristics that are linked to sex in a somewhat different manner. The explanation of these phenomena involves certain physiological conceptions of the mechanism of heredity and may be discussed more conveniently in a later section of this article (see p. 206).

Multiple Factors.—We have seen that when a fowl with a pea comb is mated with one with a rose comb, all the chicks in F_1 are alike in having walnut combs, and when these are bred together the F_2 generation shows an increased variability in characters of the comb—walnut, pea, rose, and single combs appearing. If we divide these into non-single and single the ratio is 15:1. Three pairs of allelo-

morphs would give a ratio of dominants to pure recessives of 63:1. Nilsson-Ehle (1909), on crossing a Swedish variety of red wheat with a white one obtained in F_2 a ratio of sixty-three red to one white. East (1910) in a cross between yellow and white varieties of maize obtained in F_2 fifteen yellow to one white. In this case the yellow varied from dark to light. The inference drawn from these and similar results is that we are dealing with two or more factors each dominant to its absence and each capable of producing the same or a similar somatic character. Such factors occurring in the same zygote and tending to produce the same result are called *multiple factors.*

Multiple factors exhibiting true Mendelian segregation but without dominance have been invoked to explain *blended inheritance,* expecially of size. The evidence depended upon is chiefly the increased variability in F_2 as compared with F_1. Keeble and Pellew (1910) crossed two semi-dwarf varieties of peas three to four feet tall. Plants of the F_1 generation were seven to eight feet tall, and in F_2 they varied from one and one-half to eight feet in height. These authors were able to distinguish two factors both contributing to height, one of which increased the thickness of the stem and the other increased the distance between the nodes. In rabbits derived from a cross between a small (♂) and a large (♀) variety, MacDowell (1914) compared the F_1 generation with the results of a back cross with the original small male parents (instead of F_2) and obtained increased variability in the latter.

Whether blended inheritance, as in size, is to be explained as a mere mingling of the characters of the two parents, or as the resultant of the effects of numerous segregating factors, and whether these factors if present are themselves variable, are questions still under discussion. Castle, who is skeptical as to the applicability of Mendelian laws to the inheritance of size points out (1914) that there is a high degree of correlation between various skeletal dimensions, and therefore, if there are numerous factors influencing size they must be general in their effects, not separate factors for each part, but each factor tending to modify the size of the body as a whole.

Yule (1907), on the other hand, has shown mathematically that the results of the statistical study of blended inheritance are not necessarily inconsistent with the theory of pure gametes with segregating multiple factors without dominance.

Prepotency.—This is the superior influence of one parent over the other, in determining one or more characteristics of the offspring, and was much discussed by Darwin. It is now classified with the phenomena of Mendelian inheritance.

Inheritance at Corresponding Periods of Life.—Correlations may be observed not only between adult parents and adult offspring, but also between the immature stages of parent and offsprings, and, of course, these correlations come at corresponding periods of life, or there would be no regularity in the course of development. But it has been observed that abnormalities in parent and offspring tend to appear likewise at corresponding periods of life. Of this Darwin gives a number of examples.

Characters that may be Inherited.—In general all congenital characters exhibit the phenomena of heredity, either of one type or another. This includes not only normal variations but also various abnormalities and those constitutional weaknesses that predispose the subject to disease. Pearson has shown that fertility may be inherited. As to the inheritance of modifications acquired as the result of external influences upon the cells of the body, we have but few observations of value. The results from Fay's observations on the inheritance of deafness are given in the following table:

Table VI.—Inheritance of Deafness.

Condition of parents.	Number of children.	Per cent deaf.
Both deaf, acquired	1,720	2.3
Hearing and deaf, acquired	713	2.2
Deaf, congenital and acquired	1,820	6.3
Hearing and deaf, congenital[1]	528	11.9
Both deaf, congenital	779	25.9

The difference of the results between the cases in which congenital deafness appears in the parentage and cases in which it apparently does not is very striking. It is possible that it might be still more so if it were not for the difficulty of distinguishing in every case between congenital and acquired deafness, a difficulty which may perhaps account for the appearance of even the small percentage of deaf children credited to parents that appear to have acquired deafness. The evidence for and against the inheritance of acquired characters is discussed in a previous article (see *Evolution*). We need mention here only a recent contribution by Kammerer (1913), who believes that changes in color induced in the skin of salamanders by their surroundings will influence the color patterns of their offspring. The value of his experiments is much impaired by the fact that these animals are highly variable in color, and the gametic constitution of the parents was not investigated before the experiments were begun.

Reversion.—The discussion of reversion and atavism is reserved for another place. (See article *Reversion.*)

Telegony.—Many breeders of domestic animals are firmly convinced that a previous sire may influence the progeny of a subsequent one. This supposed influence is called telegony and is regarded as a phenomenon of heredity. The subject has been investigated experimentally by Ewart, using horses and zebras, and he found no evidence of such an influence. Pearson has attacked the problem from the statistical point of view and likewise reached negative results.

In plants there is a phenomenon called *xenia.* In Indian corn when a cross is made in such a way that the pollen carries a dominant factor the maternal part of the fruit takes on the characteristics of the male parent, which one would not expect to appear until the formation of the fruit of the next generation. De Vries and Webber have explained this as due to a process of double fertilization first observed by Nawaschin and Guignard (see *Impregnation*).

In concluding our review of the phenomena of heredity it should be noted that little is to be learned by the study of isolated cases. We can acquire ideas of value in regard to heredity only by dealing with large numbers of observations by approved statistical or analytical methods. And it has been with the hope of giving some notion of the first principles of that new and important branch of biological science that we have devoted so much space to the subject. We now turn to the theories of heredity.

II. Theories of Heredity.

Importance of the Subject.—We are all interested in the question as to how we have come to be what we are, and we have seen that what we call the principle of heredity has been an important factor in determining the present condition, not only of every human being, but also of every living thing whether animal or plant. We now turn naturally to the study of the mechanism of heredity. But this is a thing which is not open to direct observation, and the best that we can do is to construct a theory of heredity from such facts as we can observe. Such an inquiry is not only of importance to the students of pure science desirous of fully comprehending the origin of organic in-

dividuals, but is equally important to the practical breeder of domestic animals and plants wishing to maintain his stock at the highest value and to the practical philanthropist anxious for the perfection of the human species. The medical practitioner is also constantly face to face with questions of heredity, and the value of his advice in such cases will depend on whether or not they are founded upon a sound theory.

Requirements of a Theory of Heredity.—A theory of heredity is not required to explain the multiplication of organisms, but it must explain the relations of form between parent and offspring. These relations are expressed by the terms heredity and variation. We have seen how intimately connected variation and heredity are with one another, that they are in fact but the opposite phases of the same phenomena. A theory of heredity, therefore, must be also a theory of variation. But heredity and variation are both the result of the process of development and to explain them one must first explain development. The embryologist has explained the development of any structure sufficiently for his purpose when he has shown how this structure is the necessary result of a certain observed order of cell division, growth, and differentiation. For him the cell is the fundamental structure, and unequal growth, fusion, and fission of tissues are fundamental processes. For the student of heredity, however, it is necessary to go deeper and to try to discover the fundamental structure of the cell itself and to investigate the minute processes of cell division to determine, if possible, the causes that result in unequal growth and differentiation and thus control the development of the organism as a whole. A theory of heredity and variation, therefore, must be also a theory of development in the deepest sense. It follows from this that our theory, to be valid, must be capable of explaining all of the phases of development, including direct development, both sexual and asexual, metamorphosis, sexual dimorphism, other forms of polymorphism, regeneration of lost parts, and the alternation of generations. It will readily be seen, moreover, that such a theory necessarily involves some conception as to the essential structure of living matter.

The Fundamental Conceptions in Theories of Heredity.—From the numerous theories that have been advanced to explain the similarity between parent and offspring there may be extracted a comparatively small number of fundamental conceptions, which we will consider in turn. These conceptions may be enumerated as follows: (1) animism, (2) physiological units, (3) heredity as a form of motion or as memory, (4) pangenesis, (5) idioplasm as distinguished from trophoplasm, (6) germ plasm as distinguished from somatic idioplasm, (7) continuity of germ plasm, (8) evolution, and (9) epigenesis.

Animism.—The earliest views as to the causes of the phenomena of heredity may generally be classed under the head of animism. Most of them agree that the character of the material body is controlled by a spiritual body, the soul, or *animus*, which enters the material body at its conception.

Van Helmont and other writers of the middle ages have supposed that there is an actual transfer of spiritual substance not only through the sexual products but also through the milk of the mother or nurse. Indeed, it is said that such is the belief of many persons at the present time.

Others believe that the thoughts of the mother may affect the mental and physical character of the developing child. Birth marks, supposed cases of telegony, and the like, have been explained in this way. When Jacob set up the rods before the cattle he was acting upon this theory.

The animistic theories have the great advantage of simplicity, but they are utterly without scientific basis and, therefore, must be rejected.

Physiological Units.—In direct contrast with the animistic theories of heredity are the materialistic theories—those that postulate a *physical basis* for heredity. One of the earliest attempts to ascribe a physical basis to heredity is that of Buffon. According to his conception, organic matter is essentially different from inorganic matter and the two are equally indestructible. *Organic molecules* are to be found everywhere and are capable of uniting to form an organism wherever they come together under certain conditions, hence his theory of spontaneous generation.

When Herbert Spencer wrote his "Principles of Biology," is was known that there is no chemical element found in living bodies that is not found also in inorganic substances and that Buffon's idea of organic molecules was without foundation. Spencer, however, made a very decided step forward when he revived the idea in another form.

If living material be separated into its constituent chemical molecules it ceases to be alive. Life is not a property of any ordinary chemical substance. Still you can divide living material, and even particles of a cell will retain for a time at least their vital properties. Therefore living matter must be made up of units, much smaller than a cell, and much larger and more complex than a chemical molecule. Spencer calls these ultimate particles of living matter *physiological units*. He regards them as possessing the physical basis of life and as being the bearers of the hereditary qualities.

Haeckel accepts Spencer's theory but refuses to believe that the physiological unit, which he calls a *plastidule*, is anything more than a very complex chemical molecule.

Weismann agrees with Spencer in regarding protoplasm as made up of units which are of a higher order than a molecule. He calls them *biophors* (the life bearers) and attributes to them somewhat different properties from those that Spencer supposes his physiological units to possess. The biophors carry with them only the elementary qualities of the organism. The true bearers of heredity are higher units, the *determinants*, which are themselves composed of biophors having certain properties and arranged in a definite order.

Nägeli takes a somewhat similar position. According to him, when proteids are formed in a watery solution they are precipitated in minute crystal-like masses that he calls *micellæ*, but they do not form part of the living material until they are united into larger masses which are drawn out into threads. These threads of micellæ are the ultimate particles of living matter and the bearers of the hereditary qualities.

Darwin, who was one of the first to give to the world a definite theory of heredity, made no attempt to discover the ultimate structure of living matter. He believed, however, in a physical basis of heredity, which he thought could be found in minute bud-like bodies, *gemmules*, given off from the various cells of the body. He was followed by Brooks and to a certain extent by Galton, and de Vries attempted to improve his theory by supposing the gemmules, which he named *pangenes*, not to be produced by the cell, but by the nucleus.

In all of these theories the bodies that are supposed to carry the hereditary characteristics are too minute for observation, and therefore it is equally impossible to prove or disprove their existence. In fact, these theories are not intended to be anything more than working hypotheses. The main question with us is, not whether one or the other of these hypotheses is correct, but whether the general principle that underlies them all should be accepted or rejected. It seems to the writer that no one who has carefully studied the phenomena of fertilization and development, and has considered the results of heredity, can

fail to believe that it has a physical basis and that this must consist of units that are much less than the cell and much more complex than the molecule.

Heredity as a Form of Motion.—The earliest theory of heredity that is sufficiently well founded to deserve serious consideration is that of Herbert Spencer. But even this theory is conceived to a great extent independently of any facts, and is therefore largely metaphysical and to be understood only in connection with Spencer's philosophical system of cosmic evolution.

He compares the organism to a crystal. The molecules which go to make up a crystal are originally all exactly alike, but in the crystal they do not all have the same relative position nor the same morphological value. One will form part of an angle, another part of a face, etc. In a similar way the organism is made up of physiological units that are all alike but differ in position. The molecules of the crystal on the one hand, and the physiological units of the organism on the other, have a certain *polarity* that causes them to unite whenever possible into aggregates having a certain definite form. If a crystal be mutilated and then placed in a saturated solution of the same salt, deposition of new material will take place in such a way as to restore the crystal to its original shape. Spencer regards the regeneration of lost parts in organisms as an exactly analogous process.

The form alike of the crystal and of the organism is due to interaction of internal and external forces. But the organism differs from the crystal in being much more sensitive to external conditions; it is due to them that variations occur. When a permanent variation is produced the polarity of the physiological units has been changed. But any force affecting a part affects the whole and, therefore, the polarity of all the physiological units in the body will be altered, including those of the germ cells. Consequently when the physiological units of the germ grow and multiply to form a new organism, they will tend to arrange themselves, not in the form that the parent had originally, but in the form that it acquired as the results of the action of external conditions. In this way all characteristics, whether congenital or acquired, tend to be inherited. According to this view heredity may be regarded as a form of motion or energy that is propagated from all parts of the body to the germ cells.

The famous botanist, Nägeli, spent the latter years of his life in working out a very complete theory of heredity that in many of its essential features closely resembles Spencer's. The threads of micellæ that, according to Nägeli, constitute the active living material are arranged in bundles which are continuous throughout the body and into the germ cells. Each thread is the seat of one of the fundamental characters of the organism, and all of the different kinds of threads necessary to make a complete organism are present in each bundle. From time to time new threads may arise, causing congenital variations in a certain definite direction. External conditions affect the micellar threads, and their reactions lead to adaptive modifications. These morphogenic stimuli set up by external conditions may be transmitted along the threads to the germ cells with the result that the adaptive modifications of the parent may be inherited by the offspring.

If a stone be dropped into the edge of a pond, the surface of the pond at that point is momentarily altered. This disturbance sets up a wave motion in adjacent particles and these set other particles in motion and so on until the wave finally reaches the farthest shore. Spencer and Nägeli think that in the same way anything that affects the physiological units or micellæ in one part of the organism sets up a sort of wave motion that extends throughout the body and into the germ cells affecting their physiological units so that they may give rise to similar modifications in the offspring. Nägeli makes an improvement on Spencer's theory in furnishing a path for heredity along the micellar threads.

Several other authors have attempted to construct similar theories, but none of them presents any advantage over the ones that have been outlined.

Haeckel's theory is intimately connected with the monistic system of philosophy and is almost entirely metaphysical. The cycle of life from egg to egg is, according to Haeckel, a great wave motion. As each individual gives rise to numerous offspring, this wave motion becomes branched with the act of generation. This branched wave motion is called *perigenesis*—and the *plastidules* of which the living material is composed have a similar wave motion, or perigenesis. Heredity is due to the propagation of this wave motion. Haeckel sums up his theory by saying that heredity is the memory of the plastidules; variability, their power of perception.

The only evidence of importance in favor of these theories is the fact that in certain tissues of animals and plants the cells are found to be connected by minute protoplasmic threads. This line of evidence has been gathered together (1898) by O. Hertwig, who calls attention also to the interesting experiments of Pfeffer, which show that in one case at least these protoplasmic filaments may transmit a formative impulse. A vegetable cell deprived of both its nucleus and cellulose wall will not regenerate either, but if the nucleus be present a new cell wall may be formed. Pfeffer prepared cells of the protonema of a moss in such a way that an isolated mass of protoplasm without a nucleus remained connected to its neighboring nucleated cell by the fine protoplasmic filaments traversing the cell wall. In such a case a new cell wall was formed around the protoplasm. But if both cells were deprived of nuclei the cell wall was not regenerated.

On the other hand, there are certainly in the bodies of both animals and plants cells that have no such connections, and a general continuity of protoplasm has not been demonstrated in any organism except in certain algæ and in the earliest stages of cleavage in the eggs of some animals. Child in a series of papers in course of publication is endeavoring to prove from the facts of regeneration in some of the lower animals that some kind of formative stimulus may pass through the body so that one part may influence the development of another.

The objection to these theories that occurs to one at once is their fanciful character and lack of any really substantial basis of fact. Their real motive is to account for the supposed inheritance of acquired characters. If any one of these theories is true, then the inheritance of acquired characters should be a matter of every-day occurrence. It is impossible to prove that acquired characters are never inherited and it is therefore impossible to disprove any such theory. But the ablest advocates of the doctrine of the inheritance of acquired characters are admitting now that such inheritance is not common, and, therefore, such a theory cannot be a complete explanation of heredity, but must represent at most only a small factor.

We may conclude, then, that the idea that heredity is a form of motion or something akin to memory cannot be accepted until more evidence in its favor is presented, and such evidence does not seem to be forthcoming.

Pangenesis.—Four years after Spencer published his "Principles of Biology," Darwin gave to the world his provisional hypothesis of "Pangenesis," as the concluding chapters in his book on the "Descent of Man."

The fundamental conception in this hypothesis had been expressed about 400 years before Christ by the Greek philosopher Democritus when he said that the seed of animals is elaborated by contributions from all parts of the body; and Buffon

likewise had supposed that the different parts of the offspring are made up of organic molecules derived from corresponding parts of the parents. But the influence that this conception has had on scientific thought is due to the brilliant manner of its presentation by Darwin.

Darwin supposed that the contributions from the various parts of the body are in the form of *gemmules*, little buds given off from each cell in the body. The gemmules circulate in the blood and are finally collected in the sexual products. When the egg develops each gemmule may give rise to cells like the one from which it was derived. Thus by a simple and perfectly intelligible process Darwin explains the inheritance by the child of the various characteristics of the parent, both congenital and acquired. All of the gemmules in the egg are not supposed to develop, but some may be passed on to subsequent generations. This is always the case with the gemmules representing the sexual characters. Individuals of one sex always contain the gemmules of the other in a latent condition. All cases of reversion are supposed to be due to the development of such latent gemmules. Other forms of variation are explained as due to the rearrangement of the gemmules in the egg, or else as due to the direct action of the environment, or the effects of use and disuse upon the cells of the parent which are transmitted by the gemmules given off from them.

The central fact upon which Darwin's theory is based is the supposed inheritance of acquired characters, but it explains equally well the inheritance of congenital variations, reversion, particulate inheritance, alternation of generation, etc. It is therefore a very complete theory of heredity.

As early as 1872, however, Galton was led to doubt Darwin's theory. He urged his objections in the first place on *a priori* grounds. He did not believe that acquired characters are generally inherited. The gemmules, he said, are purely imaginary, and therefore their existence is an unwarranted assumption. But, waiving this last objection, another and more serious one arises. If we suppose that every cell is continually giving off gemmules, the number present in the organism must be enormous; and, if every cell of the offspring is represented by a gemmule in the germ, we see that if a spermatozoon is to contain not only these gemmules, but also a large number of latent ones, in order that so many may lodge in so small a space, they must be excessively minute.

In the second place, Galton tested the question experimentally. He took silver-gray rabbits, which generally breed true, and into eighteen of these he transfused blood from rabbits of other breeds. He reasoned that, if gemmules be given off, as Darwin supposed, the blood must contain a large number, and, if blood of one breed is transfused into the body of another, the offspring of the latter should show some traces of characters of the former. Eighty-six young were reared from the individuals experimented upon, and none of them showed any trace of foreign blood.

He concluded, therefore, that pangenesis pure and simple is an incorrect hypothesis. He was willing to admit, however, that acquired characters might rarely be inherited and that this might be explained by the occasional giving off of germs by cells.

In 1876 Brooks outlined a theory of heredity which was very fully developed in his book on "Heredity," in 1883. This theory is a modification of Darwin's theory of pangenesis changed to meet the objections of Galton and others. Brooks introduced the important conception of the *continuity of the germ cells* to explain ancestral heredity, and retained pangenesis simply to explain variation. He supposed gemmules to be given off by cells only when subjected to unfavorable conditions. He further supposed homologous gemmules to unite in the germ cells and by thus producing new combinations to induce variability in the offspring. Thus external conditions affecting the parents may stimulate the production of gemmules and cause the young to vary, but not in any particular direction, for Brooks denied the inheritance of acquired modifications.

To sum up, the theory of pangenesis presented in various forms by Darwin and Brooks supposes the germ to be made up of material particles derived from all parts of the parents or more remote ancestors and able by developing to form corresponding parts of the offspring. This theory agrees with the dynamic or memory theories in supposing that the characters of the offspring depend on the character of certain physical substances in the germ, and that the germinal characters in turn are influenced directly by the corresponding parts of the parents. The theories differ in the method by which this influence is supposed to be exerted. According to the dynamic theories homologous parts of the parent and offspring are alike because the germinal rudiments of the parts of the offspring have been subjected to the influence of some sort of formative energy radiating from homologous parts of the parent. According to the theory of pangenesis, homologous parts of the parent and offspring are alike because they are of the same substance (*II.*, Fig. 3137). But these theories are found to be equally unsatisfactory when tested by the light of recent knowledge of the history of the germ cells.

Continuity.—The theory of pangenesis is intermediate between the idea of heredity as a form of energy and a third fundamental conception—*continuity* of the physical basis of heredity. This is one of the most important of the fundamental conceptions found in the more recent theories of heredity. The idea is important becaue it is founded upon the facts of observation. Like the theory of pangenesis, it attempts to discover a physical basis for heredity in the germ cells. But it differs from that theory in the view taken as to the history of the bearers of the hereditary qualities, and in regard to the relation of the germ cells to the somatic cells of the parent.

According to this theory, the germ gives rise to an individual like the parent, not because any part of the germ is derived from the parent, but because the germ which produces the offspring is a part of the *same* germ that gave rise to the parent (*III.*, Fig. 3137). An egg or a spermatozoon is a cell, and like every other cell is derived from a pre-existing cell by division. If we trace the history of the germ cells in any individual, we find that they have arisen by a succession of cell divisions form the same fertilized egg that produced the whole body (see *I.*, Fig. 3137). They are the lineal descendants of that egg, and having undergone little or no differentiation they share its qualities. The two germ cells that united to form that egg had a similar history, and so on back for all generations, and in every case this history is shared by the nucleus and more especially by the chromatin. (See article *Germ Cells.*)

Lloyd Morgan has expressed the difference between pangenesis and the theory of continuity very graphically by saying that by pangenesis the hen produces the egg which in turn gives rise to a new hen, while by the theory of continuity the hen does not produce the egg but the egg produces the hen.

The first to recognize that the germ cells differ from the body cells and are continuous in descent from generation to generation, and that this may serve to explain heredity was Sir Richard Owen, who published this opinion in 1849. Afterward, however, he denied that such an explanation is possible.

The next one to express a similar opinion was Francis Galton, writing in 1872 and 1876. He gave the name, "stirp" to the sum total of all hereditary principles, or germs, in the germ cells and, according to his theory, heredity is explained by the multiplication and transmission of this stirp.

Brooks outlined his theory of heredity in 1876 and published it in full in 1883. He says: "The ovum is a cell which has gradually acquired a complicated organization and which contains material particles of some kind to correspond to each of the hereditary characteristics of the species. The ovum, like other cells, is able to reproduce its like, and it not only gives rise during its development to the divergent cells

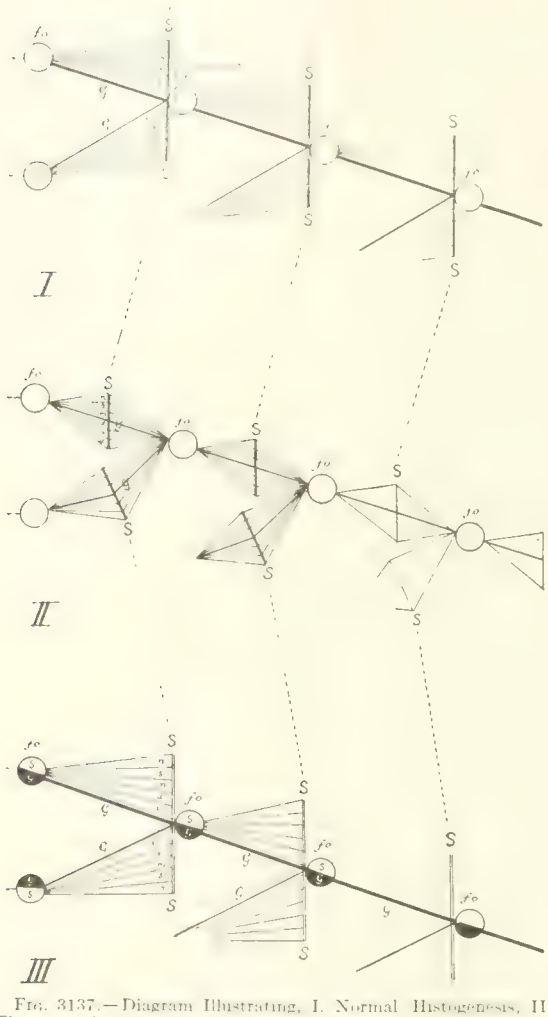


FIG. 3137.—Diagram Illustrating, I. Normal Histogenesis, II Theory of Pangenesis; III. Theory of Continuity of the Germ Plasm. The fertilized ovum (*f.o.*) by the process of cell division gives rise to the adult body, or soma (*S*), composed of *somatic cells* (*n*, *s*, *m*, *d*, *c*) constituting the nervous secretory, muscular, digestive, and other tissues, besides the *germ cells* (*G*) of the reproductive organs. I. Histogenesis, showing the successive rise, *S*, and union (*f.o.*) of the maternal and paternal germ cells by direct histogenesis. II. Pangenesis, showing the tissues of the body, *S*, contributory to the germ cells, *G*, so that each *f.o.* is composed of elements, gemmules, from both the somatic and germ cells. III. Continuity of the germ-plasm, showing the division of the idioplasm, *f.o.*, of the egg into somatoplasm, *S*, from which the body cells arise, and germ plasm, *G*, which passes directly to the germ cells establishing a direct continuity.

of the organism, but also to cells like itself. The ovarian ova of the offspring are these latter cells or their direct unmodified descendants." The child will therefore be like the mother except in so far as it is affected by new gemmules introduced chiefly in the process of fertilization. Here we have the theory of the continuity of the germ cells stated very clearly, but pangenesis is added to it to explain the origin of congenital variations.

The continuity of germ cells had been recognized by Jäger and Nussbaum in 1879 and 1880, but this did not lead in either case to any important generalizations.

From studies on the origin of the germ cells in insects and in hydromedusæ, Weismann arrived at a similar view at about the same time and quite independently, and it is due to his series of brilliant essays, beginning in 1883, that the theory of continuity has taken so important a place in recent discussions.

It was formerly believed that the primary germ-cells are formed by differentiation of somatic, or body, cells of the embryo, but much evidence has accumulated to show that they are essentially the end products of an unbroken series of embryonic cells derived directly from one or more of the blastomeres of the segmenting egg (see article *Germ Cells*).

Idioplasm.—The doctrine of continuity depends upon observations of the structure and history of the germ cells, and involves two other fundamental conceptions in regard to the relations of the parts of the cell. These are the doctrines of *idioplasm* and of *germ plasm*. We owe the first of these ideas to Nägeli. He regards protoplasm as composed of two substances. Both of these consist of proteids in the form of minute rounded micellæ and of water. In one of these substances, the "Nahrplasma" or trophoplasm, the micellæ are scattered through the water without any special arrangement. In the other substance, to which he gave the name *idioplasm* the micellæ, on the contrary, have a very definite arrangement into threads which in turn are united into bundles.

The idioplasm is the true living substance and all of the characters of the organism are due to its activities. The trophoplasm, on the other hand, is not really alive, but is the nutritive material upon which the idioplasm draws in order to grow and to make good its waste. The threads of micellæ have been mentioned before as being, according to Nägeli, the bearers and conductors of hereditary qualities. These threads constitute the idioplasm.

Weismann adopts Nägeli's conception of the idioplasm with some important modifications. He agrees with De Vries in holding that Nägeli's view that the idioplasm forms a connected network throughout the organism is untenable. According to Weismann, the idioplasm is to be looked for only in the nuclei of the cells. It is in the nucleus that new living material is constructed, and it is from the nucleus that it migrates into the cytoplasm where it is used up in the course of its functional activities—such as secretion, contraction, and the like. The formation of new material takes place in the nucleus, the functional activities of the cell take place in the cytoplasm; or, in other words, the nucleus is the seat of the anabolic processes, while the cytoplasm is the seat of the katabolic processes. According to this view, then, the cytoplasm is actively alive and not merely a mass of nutritive material, but its character is due to the stamp impressed upon it by the idioplasm within the nucleus. There is considerable evidence in favor of the view that such a division of labor between nucleus and cytoplasm really exists, as will be seen later.

Germ Plasm as Distinguished from Somatic Idioplasm.—Weismann goes a step further and divides idioplasm into two kinds—somatic idioplasm and germinal idioplasm, or *germ plasm*. It follows as a matter of course that the idioplasm of the germ cells must be capable of bearing the heredity qualities of the organism. It is idioplasm of this kind that Weismann calls germ plasm. He was led to make that distinction by the idea that then prevailed that germ cells are differentiated from somatic cells. Therefore he could not explain heredity as due simply to the continuity of germ cells, but supposed that in

younger cells of the "germ-track" (see article *Germ cells*) germ plasm and somatic idioplasm exists side by side and that heredity is due to the *continuity of the germ plasm.* He thinks that the somatic cells do not contain germ plasm as a rule, but each cell contains only a certain kind of idioplasm which constituted only a small part of the original germ plasm. Thus muscle cells contain only muscle idioplasm, liver cells only liver idioplasm, ganglion cells only nerve idioplasm, etc. It is differentiated idioplasm of this sort that he calls *somatic* idioplasm.

Many critics of Weismann refuse to accept these distinctions. They say that there is no evidence that there is any real difference between germ plasm and somatic idioplasm. We shall be better able to judge of the merits of this controversy later on. In the meantime we may employ germ plasm as a convenient term to designate the idioplasm of germ cells without implying anything in regard to the somatic idioplasm.

In view of these opinions and others that are to follow, it will be interesting at this point to glance at the evidence in favor of the theory that the nucleus is the center of control for the activities of the cell, and especially of the germ cell.

The Location of the Idioplasm in the Nucleus.—The theory that a part of the protoplasm is differentiated as an idioplasm controlling the destinies of the cell, and that this idioplasm is situated in the nucleus—more especially in the chromatin of the nucleus—rests upon three principal arguments.

In the first place a study of the phenomena of heredity shows that the correlation between parent and offspring is practically equal for both parents (see Table II.). Therefore, if the physical bases of heredity be an idioplasm, it must be contributed to the fertilized ovum in equal proportion by the two parents. Now observations show that the chromatin of the fertilized egg is derived in exactly equal proportions from the two parents, and, moreover, the chromatin is the *only* part that is equally of male and female origin. It was supposed at one time that the centrosomes of the first cleavage spindle (see *Segmentation of the Ovum*) are derived from the centrosomes of both the male and female germ cells. But it has been pretty thoroughly demonstrated in a large number of cases that the centrosome of the ovum disappears at the time of the formation of the female pronucleus (see *Ovum*) and that the centrosomes of the first cleavage spindle are either derived from the spermatozoa only or else arise *de novo,* in the cytoplasm. The centrosome, therefore, cannot be the bearer of the hereditary characteristics. Therefore, if present, the idioplasm must be looked for in the chromatinic element of the nucleus. The evidence upon which this argument is based has been discussed in the article *Chromosome.* (See also *Maturation* and *Impregnation.*)

Secondly, it is known that the correlation between homologous parts of parent and offspring is approximately equal for all parts of the body in which the heritage is blended. From this it is evident that physical basis of the hereditary characteristics must be distributed equally from both parents to all parts of the body of the offspring. Now we know that all cells of the body are derived by fission from one single cell, the fertilized ovum. Further, during the first division of the ovum the chromosomes are divided in such a way that the two daughter cells receive chromatin of both male and female origin in exactly the same proportion as found in the fertilized egg; and in each subsequent cell division the chromatin is distributed equally between the daughter cells. Therefore we may infer that under ordinary circumstances the chromatin of every cell in the body is equally of maternal and paternal origin—provided that it can be shown that the chromosomes maintain their individuality during the so-called resting stage between two cell divisions. It is well known that there is no appearance of such individuality in most resting nuclei. Nevertheless, as the reader may see by reference to the article *Chromosome,* there is a considerable body of evidence to show that this is only an apparent loss of individuality, and that the chromosomes formed preparatory to division are essentially the same as those present at the end of the previous fission, only grown larger.

Historically, then, the chromatin fulfils all the requirements of the supposed idioplasm. It remains now only to examine the third argument, that the chromatin and the nucleus, which contains it, have a controlling effect more than other parts upon the activities of the cell, especially upon the formation of structures.

As early as 1877 Brandt showed that fragments of a protozoan, if lacking a nucleus, would die quickly, while portions containing nuclear material would heal their wounds and live. These observations have been confirmed and extended by Nussbaum, Gruber, Verworn, Lillie, and others. They find that enucleated fragments of various protozoa may live under favorable conditions for a number of days, or even weeks, and "will perform perfectly normal movements, show the same susceptibility to stimulus, and have the same power of engulfing food as nucleated fragments." "They lack, however, the power of digestion, secretion, and regeneration." In like manner, if a nerve fiber be cut in two the portion connected with the cell containing a nucleus lives and grows, while the distal portion dies and disintegrates. Verworn has found, however, that an isolated nucleus is equally incapable of regeneration, and Lillie has shown that in Stentor a fragment containing a nucleus cannot regenerate its lost parts if the cytoplasm is reduced beyond a certain amount—one-twenty-seventh of the original volume in this case. From this it is evident that the life of the cell depends upon the combined activities of the nucleus and the cytoplasm. Perhaps regeneration is impossible because the means of engulfing food have been destroyed. It does not disprove the theory that the nucleus is the nutritive and dynamic center of the normal cell, a theory that is supported by several other lines of evidence.

The *position* of the nucleus indicates that it plays an especially important part in the economy of the cell. For example, Haberlandt (1877) showed that in plants the nucleus lies nearest that part of the cell which is undergoing most rapid growth, as in the formation of root hairs, thickening of cell walls, etc.; and Korscheldt (1889) has called attention to the fact that in animal cells the nucleus lies on the side nearest the source of food supply. Changes in the *form* of the nucleus indicate the same thing. In both animals and plants it has been seen that in cells actively forming new material the nucleus becomes enlarged, and sometimes branching. Moreover, an actual *transfer of material* from the nucleus to the cytoplasm has been observed. Hodge found that the nuclei of ganglion cells shrink during functional activity. In cell division all parts of the nucleus except the chromosomes and sometimes parts of the chromatin disappear in the cytoplasm. They may be lost as products of metabolism, but it is probable that part of them remain as permanent structures in the cytoplasm. Upon the formation of a new nucleus after division the nuclear membrane, linin network, and nucleoli are regenerated from the chromatin.

Finally, we have the interesting experiments of Boveri, which, while unfortunately not perfectly conclusive, tend to show the great importance of the nucleus in heredity. He mixed fragments of eggs of one species of sea urchin with spermatozoa of another and obtained dwarf larvæ, presumably by the union of spermatozoa with enucleated egg fragments, and these larvæ possessed purely paternal characteristics.

Herbst (1909) has obtained a similar result in

another way. By treating sea-urchin eggs with dilute valerianic acid he first started their development and then added sperm of another species. The sperm-nucleus was passed as a whole into one of the first two blastomeres and fused with its nucleus. The resulting larva was purely maternal on one side and hybrid in character on the other. There can be little doubt that this difference is the result of difference in nuclear constitution.

In the cells of higher plants, there are small protoplasmic bodies called *plastids*, and some of these are the chlorophyll bodies and give the color to the plant. Plastids multiply by fission. They are present in the egg cell and are passed on to the daughter cells in cell division. But there are no plastids in the pollen tube so that these structures if they are, as they appear to be, permanent cell organs, are of purely maternal origin. Nevertheless, hybrid plants inherit dominant colors as strongly from the male as from the female parent, showing that the male component of the nucleus influences the character of these apparently independent plastids.

It is well known that the character of the grain of Indian corn is modified by the kind of pollen that falls upon the stigma. The part affected seems to be of purely maternal origin and this phenomenon, known as xenia, was for a long time an unsolved puzzle. Webber has suggested that its explanation is to be found in the discoveries of Guignard and Nawaschin, that in the lily and Fritillaria there is a double fertilization. While one nucleus from the pollen tube unites with the nucleus of the egg cell, a second one from the same source unites with the nucleus of a cell that by its division is to give rise to the main part of the seed. If the same process can be shown to occur in maize, then xenia is explained and the important formative influence of the nucleus is demonstrated, for there is no evidence that any other structure passes from the male plant into the embryo sac.

Preformation and Evolution.—The theory of continuity postulates that the child and its parent are alike because both of them have been produced by the same germinal substance. This is a satisfactory explanation of heredity so far as it goes, but it leaves unanswered two large questions, How is variability introduced? and How is differentiation brought about? An attempt to answer these questions involves us at once in the old controversy of Evolution *vs.* Epigenesis (see *Evolution*).

The observations of Wolff, von Baer, and their successors settled this controversy forever so far as the visible phenomena of development are concerned, but the question acquired a new meaning with the advent of scientific speculation on heredity.

Darwin's theory of heredity was the first one in which the theory of preformation was clearly stated. He regarded the egg as made up of gemmules each one of which is capable of growing and producing one or more cells of a certain definite part of the body. Differentiation is merely the development of the different kinds of gemmules. Congenital variations are due to the transmission from the parent of gemmules having new qualities. Every part of the embryo is represented in the egg by one or more gemmules. The embryo is, therefore, just as much preformed in the egg as it was according to the views of Bonnet a century earlier.

Brooks differs from Darwin in his theory of the origin of the gemmules and of the kind of variability that they produce, but he fully agrees with him as to their function in development. He regards a theory of preformation as the only kind of theory of development that can be defended.

Before Brooks published his theory Wilhelm His, in 1875, presented a theory which has had considerable influence upon subsequent thought. He did not attempt a complete theory of heredity, but aimed to explain only development and differentiation. He rejected the hypothesis of gemmules and relied upon two principles: (1) the principle of differentiation of areas (Princip der organbildenden Keimbezirke) and (2) the principle of unequal growth. He had in mind an egg like that of any of the higher vertebrates, in which the embryo is formed in what is practically a flat blastoderm (see *Area embryonalis*). According to his views the embryo is mapped out at first upon the surface of the egg, each organ and part of organ being represented by a certain area (differentiation of areas). These different areas of the egg differ from one another in density, viscosity, chemical composition, etc., and therefore, when growth begins, it occurs at different times and to different degrees in the different parts. This unequal growth results in the well-known processes of folding, invagination, and the like.

The principle of unequal growth is now universally accepted as one of the fundamental principles of modern embryology. So far as it goes it is undoubtedly a correct theory of development, but we still want to know what causes this inequality. It is due, according to His, to the differentiation of areas; but he does not explain how they arise.

Development, according to His, is clearly a process of evolution. In 1888 Roux published the results of some experiments on frogs' eggs that would seem to demonstrate the truth of the principle of differentiation of areas, or germinal localization, as Wilson calls it. By puncturing one blastomere in the two-cell stage he could kill the blastomere operated upon without affecting the other. The result of the operation was that, while the injured blastomere remained inactive, the uninjured one developed into a complete half embryo. Apparently the right and left halves are predetermined in the egg before it divides.

But in the mean time Nägeli had published his idioplasm theory, and various observations upon the functions of the nucleus in fertilization and development had made it seem probable that the idioplasm should be looked for in the chromatin of the nucleus. Roux, therefore, did not look for the predetermination of the two halves of the embryo in the cytoplasm of the egg, as His would have done, but sought for it in the nucleus. In fact, he had five years before these experiments presented the important idea that the chromatin may divide in two ways. It may undergo a *quantitative* division which results in *growth*, by division of the cell into two similar cells, or it may suffer a *qualitative* division, which results in differentiation by the division of the cell into two dissimilar cells. The first cleavage of a frog's egg would be, accordingly, a qualitative division separating the idioplasm of the right side from that of the left.

De Vries in 1889 seemed to help the theory of preformation by supplying a reasonable hypothesis to account for the control of the cell by the nucleus. Although he calls his theory "intracellular pangenesis," it has very little resemblance to Darwin's theory. According to de Vries, the idioplasm has the same composition in all the cells of the body. It is composed of minute particles called *pangenes*, each one of which, like a micellar thread of Nägeli, represents one of the elementary qualities of the organism. The pangenes in the nucleus are in an inactive, or latent, condition and only a few pangenes of each of the many kinds are to be found there. The cytoplasm is made up likewise of pangenes surrounded by a nutritive fluid. But, unlike the nucleus, the cytoplasm contains a great number of pangenese of only a few kinds, and they are all in an active condition. From time to time a pangene in the nucleus will divide. One-half remains in the nucleus, the other half migrates into the cytoplasm, where it may undergo repeated divisions. In this way the nucleus controls the cell, while at the same time its idioplasm remains unchanged. Differentiation is brought about by different kinds of pangenes becoming active in different cells.

De Vries argues that various hereditary qualities must be represented by separate material factors, because these qualities may vary independently of one another. It may be supposed that the nucleus controls the cell by liberating some form of energy which acts as a stimulus. But this implies something in the cytoplasm having definite vital properties to receive the stimulus. Or it may be thought that the nucleus secretes a ferment, but this again implies something in the cytoplasm for the ferment to act upon. This something in the cytoplasm requires to be explained, and de Vries concludes that the only tenable hypothesis is that the control of the cell by the nucleus is exercised, not through any power of stimulation nor by means of a ferment, but through the migration of particles of the nucleus into the cytoplasm, of which they then form a part.

We come now to a theory of heredity where the theory of evolution, or performation, is carried to its ultimate conclusion. This is the theory of Weismann, which has for its basis the hypothesis of the continuity of the germ plasm with the total denial of any inheritance of acquired characters. Superimposed upon this is the idioplasm theory of Nägeli, the theory of qualitative cell-divisions of Roux, and the theory of intracellular migration of pangenes of de Vries.

As has been stated before, heredity pure and simple is explained by Weismann as due solely to the continuity of the germ plasm, some of which is held in reserve in each individual and is passed on to the next generation without receiving any formed material from the somatic idioplasm. We use the term *formed* material, for, of course, the germ plasm receives nutriment just as do all other living parts of the body, and it utilizes this in growth. Weismann rejects entirely both the dynamical and the pangenesis theories of heredity.

According to this view strictly new congenital characters can arise only by the modifying influence of external conditions acting directly upon the germ plasm. External conditions which may affect the germ plasm in this way are food, temperature, and perhaps chemical composition of the surrounding medium. Any change in these factors of the environment may affect the germ plasm within an individual and result in the appearance of a new character in its offspring. The appearance of really new characters, however, is rare. Most variation is brought about by new combinations of old characters, just as any number of new words may be constructed from the twenty-six letters of the alphabet, and innumerable combinations of this kind are produced according to Weismann by sexual reproduction.

The process of fertilization results in the bringing together of two masses of germ plasm having slightly different histories, and, therefore, slightly different qualities. This mingling of two germ plasms is called by Weismann the process of *amphimixis*. In this process the two germ plasms do not fuse, for if they did the child would always have the average character of its parents. As a matter of fact this is a rare occurrence; the individual child is more apt to resemble one parent or a grandparent. We must suppose, therefore, that the germ plasms derived from each parent remain as distinct units in the child, and Weismann calls each one of these units an *id*. If there existed an animal in which sexual reproduction had never taken place its germ plasm would consist of a single *id*. That such units do exist in all organisms now living is show, according to Weismann, by the presence of a special device for preventing the doubling of the ids that would otherwise occur with each sexual act. This is the reducing division that always precedes fertilization (see *Maturation*).

Weismann does not think that the chromosomes are the ids, which of course lie within the nucleus, but he thinks that the small granules of which they are sometimes seen to be composed may be the ids, and therefore he would substitute the word *idant* for chromosome. Each idant of the germ cell he regards as composed of a large number of ancestral germ plasms, or ids, any one of which is capable of directing the entire development of the organism.

Now each id cannot be a homogeneous unit, for we find that a child may resemble one parent in some particular, the other parent in another particular, and perhaps a grandparent in a third, and connected with this there is frequently a lack of correlation so that not only different parts of the adult but different stages in its ontogeny may be independently variable. As Galton puts it, inheritance is particulate. Each id must therefore contain at least as many smaller units as there are independently variable parts in the organism. Weismann calls these units *determinants* The id, then, has a certain structure. It is composed of determinants that are arranged in such a definite way in relation to one another that they give rise to an organism of their species. Each determinant may control a single cell or a large number of cells if they all vary together.

But a cell may vary in part and not as a whole. Moreover, the determinant must be supposed to reside in the nucleus and its control over the cell must be accounted for. The determinant must, therefore, be composed of still smaller units which are able to pass out from the nucleus and become a part of the cytoplasm, as the pangenes of de Vries are supposed to do. Weismann points out that we must not regard protoplasm as a chemical substance composed simply of atoms and molecules, for no chemical molecule has the power of assimilation and growth. We have to suppose the living material to be a structural combination of dissimilar molecules. These molecules must be arranged in groups, thus forming units of protoplasm which have the power of assimilation, growth, and multiplication by division, but which if further divided would be separated into their constituent molecules and would then cease to be living matter. These units Weismann calls *biophors*. He insists that their existence is not a mere assumption, but that they must exist. All living material is composed of them, and he asserts that the nucleus exerts its control over the cell body by means of the biophors, which pass through the nuclear membrane and become a part of the cytoplasm, like the pangenes of de Vries. Each determinant, therefore, must be composed of a large number of biophors, and when the part that it controls, its *determinate*, presents a differentiation of parts, it must contain a different kind of biophor for each part.

This, then, is Weismann's conception of the structure of the germ plasm. We can understand now from his point of view how ontogeny would take place. Suppose a species where reproduction had always taken place by means of an unfertilized egg, the simplest possible case, then the germ plasm would consist of a single id containing one determinant for each independently variable quality of the species, and each determinant would contain at least as many biophors as there are distinct parts in its determinate. Now before cleavage begins each determinant divides into two, and one set of determinants forms an id of reserve germ plasm, which is to be handed on to the future offspring; while the other forms the idioplasm for the developing organism. The first stage in development is the rapid growth of one determinant of the active id. This is followed by its division into its constituent biophors, which migrate out of the nucleus into the cytoplasm of the egg and cause it to divide into the first two blastomeres. With the division of the cell, the id and its determinants likewise divide, so that each cell contains an id, but this is no longer an id of germ plasm but an id of somatic idioplasm, for it has been changed by the loss of the determinant that was used up to cause the first division. At least one cell, however (corresponding to

the cell P_1 in Ascaris, Fig. 2766 article *Germ Cells*) will contain, besides its own particular id of active idioplasm, also an id of inactive reserve germ plasm. Ontogeny thus proceeds by the orderly division of the determinants and the separation of their biophors. In the course of ontogeny two kinds of cell division will occur. In one the daughter cells will have the same hereditary qualities; in the other they will be unlike. In the first, the division of the id is preceded by the division of each determinant into two; in the second, there is no division of the determinants, but they become separated into two sets, one of which goes to form each new id. Thus at the first cleavage one nucleus may contain all the determinants for the ectoderm and the other all of those for the endoderm, or one may contain all determinants for the right side of the body and the other for the left. When ontogeny is completed the idioplasm of each cell contains but a single determinant, which continues to control the cell by sending fresh biophors into the cytoplasm to replace those that are used up in performing their functions. In addition to this, each cell in the germ track contains a complete id of reserve germ plasm, which remains inactive or simply grows without influencing the cell which contains it.

Now probably in the history of all living organisms sexual reproduction has occurred during innumerable generations. The germ plasm would therefore consist not of a single id, but of a great many. Each one of these would behave in ontogeny, however, just as we have supposed the single one to act.

Now we can see how sexual reproduction aids variation. When there was but a single id of germ plasm, congenital variations could arise only by the slowly modifying influence of external conditions upon its biophors and determinants; but with sexual reproduction we have brought together a number of ids differing slightly in hereditary qualities and each trying to control the development, the result will bring about variation.

The determinants in the various ids will be related in two ways. Those determinants are homologous that control homologous parts of the body, and homologous determinants may again be either homodynamous or heterodynamous to one another, according as they have the property of impressing the same or a different quality upon the part that they control.

When the homologous determinants of the two parents are homodynamous, the offspring will possess the quality that they control in a greater degree than either parent. When they are heterodynamous there will be a struggle between the determinants and the quality in the offspring will be dependent upon the relative strength or numbers of the two sets. All of the determinants from one parent are not likely to have the same relative strength, and hence it is that the child generally resembles one parent in some peculiarities and the other one in others.

If we accept this theory of the structure of the germ plasm, it is easy to explain all of the phenomena of heredity and development.

According to this theory every peculiarity of the organism in every stage of its development is represented by a distinct and definitely located structural element in the germ plasm. Development is an evolution, a becoming visible of pre-existing potentialities.

On its face it is a very satisfactory theory, but we shall find that when tested by experiment it fails in many parts.

Epigenesis.—As was noted at the beginning of the preceding section, if we start with the idea of continuity of idioplasm as the basis for a theory of heredity, we soon find ourselves involved in the question as to whether development and differentiation are due to preformation and a process of evolution or are due to a process of epigenesis. Just as we may take Weismann as the champion of the preformation theory, so may we take Oscar Hertwig as the champion of the more extreme side of the theory of epigenesis. His position is supported to a greater or less degree by de Vries, Dreisch, and E. B. Wilson.

Hertwig agrees with Weismann in regarding heredity as being due to a continuity of germinal idioplasm which resides in the nucleus and controls the activities of the cell by migrating out of the nucleus into the cell body and there becoming part of the active cytoplasm. Like Weismann he supposes the idioplasm to be made up of minute structural elements which have the power of assimilation, growth, and reproduction by fission; but he differs from Weismann in regard to their other qualities. He calls these bodies *idioblasts* and they correspond in general to Weismann's biophors, to de Vries's pangenes, and to Nägeli's micellar threads.

According to Weismann, the germ plasm is made up of determinants that represent every part of the body that may vary independently, whether this be made up of one cell or of a group of cells. According to Hertwig, on the other hand, the germ plasm is made up of idioblasts that represent only cell characters. All of the different cellular structures that may occur anywhere in the organism may be represented by separate idioblasts in the germ plasm, but characteristics that depend upon combinations of cells cannot be represented there. The egg and the spermatozoon are cells formed by fission from preexisting cells, and the fertilized egg is likewise a cell capable by division of giving rise to a colony of cells. An egg may contain elements representing nerve fiber, muscle fibrillæ, and the like, because these structures may occur within a cell; but it cannot contain elements representing a hair or a biceps muscle; for hair and muscle are formed only by the union of many cells, and it is impossible to suppose that characters which can be formed only by the union of many cells may be represented in the structure of a single cell. Nevertheless, Hertwig agrees that the characteristics of the adult depend fundamentally upon the structure of the idioplasm in the fertilized egg from which it springs. He compares the organism to a *state*. If we suppose a community or a state to be composed of the offspring of a single pair, the schools, the markets, the courts of justice, and all departments of the government will be the result of the character of that first man and woman, and yet it would be absurd to suppose that these institutions were present in them in a latent condition. Just as all the characteristics of such a state will be the necessary result of the human nature of the man and woman from which it has descended, so all characteristics of the organism are ultimately due to the cell nature of the fertilized egg from which it has developed. We find Hertwig, therefore, opposing two of Weismann's fundamental conceptions, viz., *preformation* and the *qualitative* division of the idioplasm, and it would be well to make a digression here to test these ideas by the results of experiment.

Let us take up first the facts of normal development. According to Roux's theory of qualitative divisions, which is one of the fundamental conceptions of Weismann's theory, the egg is at first *isotropic*, that is, there is no predelineation of the embryo or of its planes of symmetry in the cytoplasm. But when cleavage begins, the qualitative divisions of the idioplasm have the result that the embryo becomes a mosaic made up of cells having different qualities and capable of giving rise only to certain definite parts of the definitive organism. This is called the mosaic theory of development.

As already pointed out, Roux found evidence for his theory in his experiments on frogs' eggs. Since then other evidence has been produced. Crampton experimenting on the eggs of a marine gasteropod (Ilyanassa) found that isolated blastomeres from embryos in the two-cell or four-cell stage (Fig. 3138), "exhibit a typical partial development; that is, each

one develops as if the missing portions of the embryo were present. No regeneration of the missing parts takes place." This bears out what we are led to expect from a study of the normal cleavage of the gasteropods and annelids, two large groups in which the method of cleavage is almost identical. The division of the egg in these groups follows a complex but very definite plan. Wilson found that in Nereis every cell division follows a prescribed order up to the fifty-eight-cell stage. At that stage the chief organs of the body are represented by separate cells. Similar results have been obtained by later investigators working upon the development of other annelids and on molluscs. Conklin has traced the cell lineage in Crepidula to the one hundred and nine-cell stage (Fig. 3139). The cells appear in such definite and similar succession in the various species that each cell has been given a distinctive designation, and the history of each cell division has been traced to the time when the principal organs are outlined. In such a form the embryo is really "a visible mosaic work, not one ideally conceived by a mental projection of the adult characteristics back upon the

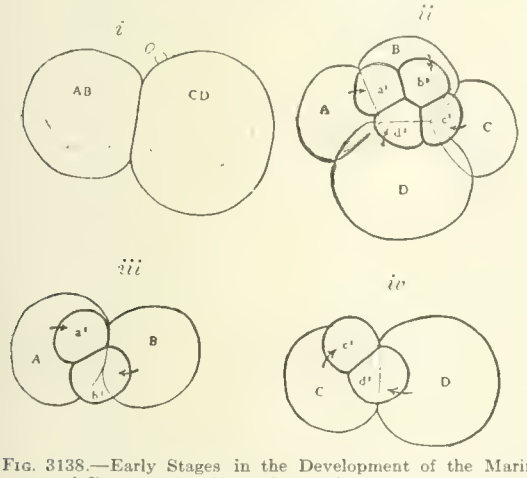


Fig. 3138.—Early Stages in the Development of the Marine Gasteropod, Ilyanassa. *i.*, Normal two-cell stage; *ii.*, normal eight-cell stage; *iii.*, half eight-cell stage developed from the smaller isolated blastomere, AB; *iv.*, half eight-cell stage developed from the larger isolated blastodmere, CD. × 112. (After Crampton.)

cleavage stages." There can be no doubt about the truth of these observations, and if they constituted all of the evidence, Roux's theory of qualitative divisions and of the mosaic character of the embryo would be fully verified.

Unfortunately for the theory, however, there is a great mass of evidence to show that these observations must be interpreted differently.

Beginning with the phenomena of normal development, observations of Miss Clapp on toad fish, and of Morgan on other Teleosts and on frogs, show that there is no constant relation between the first cleavage plane and any plane of the adult body. Observations of H. V. Wilson on the sea bass, of Jordan on Amphibia, and of E. B. Wilson on Amphioxus show that there may be considerable variation in the process of cleavage and yet normal embryos will result. E. B. Wilson found three types of cleavage in Amphioxus, a radial form, a spiral form, and a bilateral form, with all grades between, and all of these are equally capable of producing normal larvæ.

These cases are enough to prove that the mosaic theory is not universally applicable, and there is experimental evidence that is still more convincing.

Driesch was the first to experiment with segmenting eggs under *pressure*. Ordinarily in the sixteen-cell stage of an echinoderm egg the cells are separated by alternate vertical and horizontal planes. Driesch found that if the fertilized egg was compressed between glass plates cleavage would take place, but all the planes would be vertical, so that at the end of the sixteen-cell stage the embryo would consist of a one-layered plate of cells. Relations of the nuclei in such an embryo would be very different from the normal, yet if the pressure were now released the embryo would develop into a perfect larva.

Hertwig obtained the same results from experiments on frogs' eggs. These are of more interest because of the early differentiation of the egg into micromeres and macromeres. Hertwig obtained a different mode of cleavage, according as he compressed the eggs

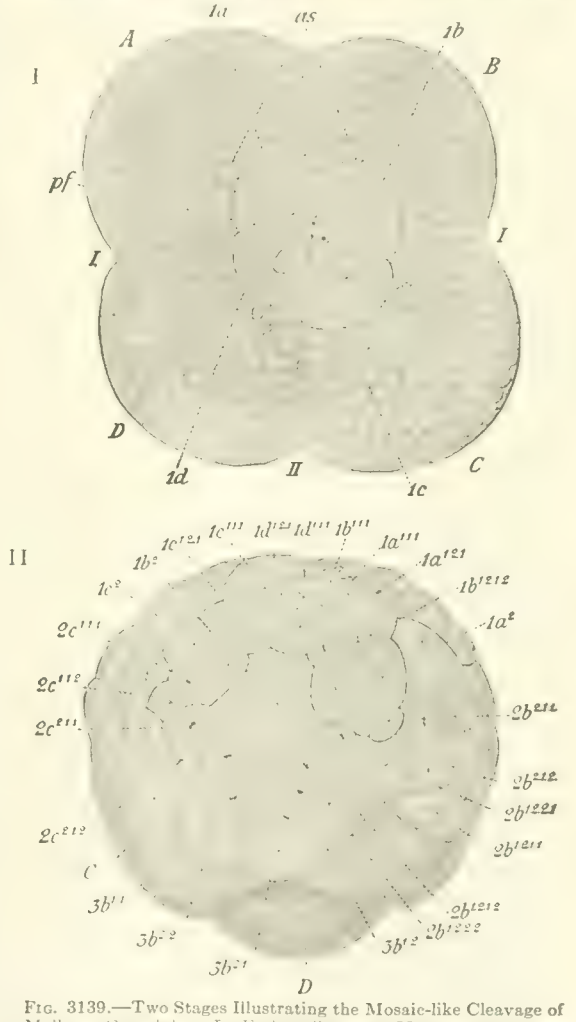


Fig. 3139.—Two Stages Illustrating the Mosaic-like Cleavage of a Mollusc, Crepidula. *I*, Eight-cell stage; *II*, stage with one hundred and nine cells. Highly magnified. (After Conklin.)

between horizontal or vertical plates, and both of these forms were found to differ very greatly from the normal, cells becoming macromeres which should normally be micromeres and *vice versa*. Yet upon pressure being removed all developed into normal embryos.

The most interesting experiments in this line are a few performed by E. B. Wilson on fertilized eggs of Nereis (Fig. 3140). They are especially interesting because of the great definiteness of the cleavage in Nereis and because of the results that Crampton obtained from the isolation of the blastomeres of Ilyanassa. Under pressure beneath a cover-glass,

the eggs would divide, each forming a flat plate consisting of a single layer of eight cells. "If they are now released from the pressure, each of the cells divides in a plane approximately horizontal, a smaller granular micromere being formed above, leaving below a larger clear macromere in which the oil drops remain. The sixteen-cell stage, therefore, consists of eight deutoplasm-laden macromeres and eight protoplasmic micromeres (instead of four macromeres and twelve micromeres, as in the usual development). These embryos developed into free-swimming trochophores containing eight instead of four macromeres, which have the typical clear protoplasm containing oil drops. In this case there can be no doubt whatever that four of the entroblastic nuclei were normally

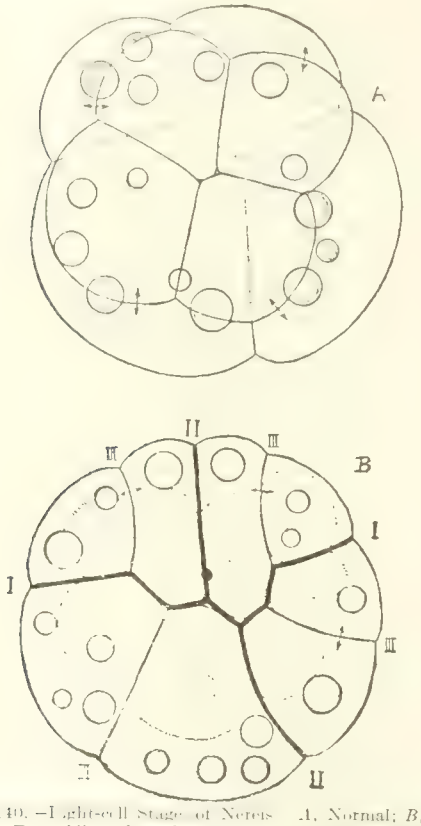


FIG. 3140.—Eight-cell Stage of Nereis. *A*, Normal; *B*, under pressure. Dotted lines show the outlines of the micromeres formed after release from pressure. (After Wilson.)

destined for the first quartet of micromeres (ectoblast) from which arise the apical ganglia and prototroch. Under the conditions of the experiment, however, they have given rise to the nuclei of cells which differ in no wise from the other endoderm cells. The immediate cause of differentiation must therefore be sought not in the distribution of the nuclei or their mode of division, but in the conditions existing in the cytoplasm."

This conclusion is borne out by the converse experiments performed by Morgan upon the egg of Fundulus In this minnow, as in other fishes, the blastoderm in the eight-cell stage consists of a single layer of cells lying on one side of the yolk. Morgan discovered that by pricking a fertilized egg so that part of the yolk escaped, he could apparently reduce the pressure on the germinal disc, which would become rounded and would divide so that the eight-cell stage consisted of a clump of cells separated by two vertical and one horizontal planes. But in spite of this abnormal cleavage a normal embryo was produced.

The results of the *isolation* of blastomeres are complicated. On the one hand we have experiments like Crampton's, where an isolated blastomere of the two-cell stage continues to develop into a half embryo, as if the other half were present; while, on the other hand, we have the experiments of Zoja, who found that isolated blastomeres of the medusæ, Clytia and Laodice, in the sixteen-cell stage would develop into free-swimming larvæ which could not be distinguished, except for their small size, from larvæ developed from whole eggs. (Apparently, however, a one-fourth egg of Clytia was the smallest that would develop into a complete medusa.) Between these two extremes there are species presenting intermediate grades in their capacity to develop from isolated blastomeres. So far as we know now, the form that comes nearest to the medusæ described by Zoja in power to develop from isolated blastomeres is Amphioxus. Wilson discovered that blastomeres of the two-cell stage isolated by shaking would develop precisely like whole eggs, giving rise to perfect blastulas, perfect gastrulas,

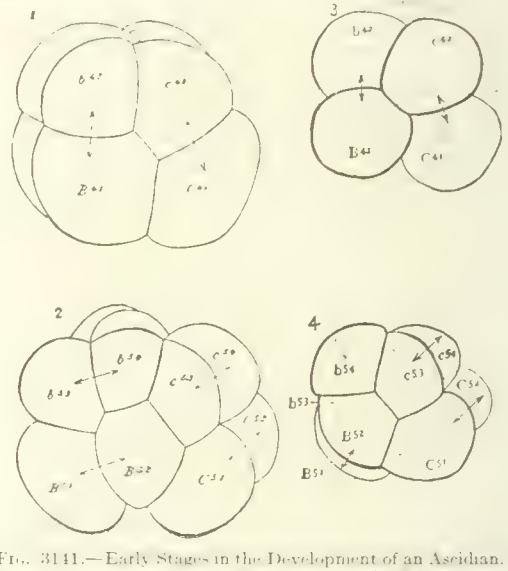


FIG. 3141.—Early Stages in the Development of an Ascidian. 1, Normal eight-cell stage, viewed from the left side. 2, same, sixteen-cell stage; 3, half eight-cell stage developed from an isolated left blastomere of the two-cell stage; 4, same in the half sixteen-cell stage. Note the relative positions of corresponding cells, $B^{4.1}$, $B^{5.2}$, etc., in normal and half embryos. × 250 to 280. (In part after Castle, from Crampton.)

and nearly perfect larvæ one-half the normal size. The same result was obtained from groups of two blastomeres of the four-cell stage. Single blastomeres of this stage, however, might give rise to perfect blastulas and gastrulas, but the larvæ were less perfect. While from the eight-cell stage single blastomeres would produce only imperfect blastulas, most of them developing as if still part of a whole embryo. Morgan found that if one blastomere of the two-cell stage of Fundulus were killed, the other would develop into a perfect embryo two-thirds of the normal size.

An isolated blastomere of the sea-urchin, Echinus, according to Driesch, develops at first as if it were a half of a whole embryo producing a half blastula. Then the opening closes forming a complete blastula which develops into a gastrula and pluteus. Crampton obtained similar results with eggs of an Ascidian (Fig. 3141).

In the ctenophore, Beroe, we have, as Driesch and Morgan have shown, a condition similar to that found in the gasteropod. Isolated blastomeres of the two- or of the four-cell stage segment as if forming a half or

a quarter of a whole embryo, and they give rise finally to imperfect larvæ. Driesch and Morgan made also the interesting discovery that if a fertilized ctenophore egg have part of the cytoplasm removed, it also gives rise to an imperfect larva "showing certain defects which represent the parts removed." This last observation shows that the cytoplasm may be of importance in directing development. For here a defect in the cytoplasm gives rise to a definite deformity in the larva.

All of these results, taken together, make a very strong case against the theory of qualitative divisions. The isolation experiments show that in many cases a nucleus which normally should give rise to nuclei of only one-sixteenth, one-eighth, one-fourth, or one-half the embryo may when isolated produce all of the nuclei of a normal larva. The pressure experiments show, moreover, that even in cases in which isolated blastomeres will not produce whole larvæ, these same blastomeres, if all together, may be shuffled like a pocket full of marbles and yet produce perfect larvæ. Evidently we must seek some cause other than qualitative divisions to explain differentiation.

According to Weismann's theory of determinants, we must not only have qualitative divisions, but the cells of the body must become diverse by a process of self-differentiation. That is to say, the cause of differentiation lies within the cell itself and not only within the cell but in the idioplasm residing in the nucleus. There is no room left in this process for the effects of external conditions. Hertwig, on the other hand, maintains that external conditions form a very important factor in differentiation. That this must be true is demonstrated by the numerous modifications of form that occur as reactions to external stimuli. (See article *Differentiation.*)

It should be borne in mind in this connection that if the idioplasm resides in the nucleus, as we have reason to believe that it does, then the yolk and other constituents of the cytoplasm in the same cell form part of the external conditions relative to the idioplasm. Since the days of Balfour morphologists have universally accepted the belief that the presence of yolk has a profoundly modifying effect upon the course of cleavage.

Morgan and Driesch have presented experimental evidence that not only is this true, but that later stages may be affected by the presence or absence of portions of the yolk in the egg.

Hertwig maintains in opposition to Weismann that the fertilized egg is after all merely a cell, and can have no characteristics other than those that properly belong to cells. The impulse for the first division comes either from the nucleus or the centrosome, but the plane of the division is determined by the shape of the egg, the distribution of the deutoplasm, its relative amount, the plane of union of the pronuclei, and so forth. As soon as the organism consists of more than one cell, the interaction of one cell upon another affects the mode of cleavage and the differentiation of the cell. At the same time the cells are being affected by stimuli from without the organism, such as light, heat, gravity, and chemical composition of surrounding media. Although the cytoplasm may divide into parts differing in composition and specific gravity, the division of the idioplasm in the nucleus is always *quantitative* only. The two daughter nuclei are exactly alike. Nevertheless, the nucleus controls the differentiation of the cell, and this is affected by the different idioblasts which become active in different nuclei. Which idioblasts shall become active in any cell is determined by the different positions of the nuclei relative to the whole mass and the consequent difference in the stimuli that they receive. Hertwig quotes with approval the remark made by Driesch that "the differentiation of the cell is a function of its position."

The new characters that appear in ontogeny are really new formations and not merely the becoming visible of preexisting latent possibilities. The form of the embryo is the resultant of two factors, viz., the character of the idioplasm, and the nature of the stimuli to which it is subjected. Of these stimuli, those which arise within the organism are the most important in ontogeny, for they are the ones that are constantly changing as development proceeds. The character of the idioplasm determines primarily what the reaction shall be to any given stimulus, and this reaction in turn determines what the stimulus shall be in the next stage. Development is purely a process of epigenesis, and each stage determines only what the next stage shall be.

Current Theories.—While the evidence from experimental embryology seems on the whole to be against Weismann's theory of differentiation and there is doubtless much truth in the position taken by Hertwig, nevertheless Weismann's theory of heredity has been much strengthened and confirmed in other respects by subsequent investigations. This confirmation has come from three sources: study of (*a*) the maturation of germ cells, (*b*) the determination of sex, and (*c*) Mendelian inheritance.

Some of the main points in which Weismann's theory has been confirmed are: (*a*) continuity of the germ plasm, (*b*) locus of the germ plasm in the chromosomes, (*c*) individuality of the chromosomes and the reducing division in maturation, which he predicted, (*d*) equality of the paternal and maternal contributions to the germ plasm, (*e*) preformation in so far as each unit-character is represented in the germ plasm by a determinant, now generally called a factor, or gene, which is probably a material particle occupying a definite position in a definite chromosome.

Weismann's conception of the structure of germ plasm has been much simplified. Instead of many ids, it is now seen to be composed of but two ids, one of paternal and one of maternal origin, each one including half of the ordinary chromosomes and a proportion of the sex chromosomes that varies with the species. In the process of maturation the chromosomes are redistributed, so that each gamete contains one id of mixed origin in which may be found any possible combination of paternal and maternal chromosomes. That the chromosomes in each id bear different factors is made highly probable by the exact parallel between the distribution of the chromosomes in maturation (*q.v.*) and the distribution of independent unit-characters in Mendelian inheritance.

This probability is vastly increased by the discovery of a constant relation between sex and certain chromosomes, the "X-chromosomes." In a simple case, like the fruit-fly, Drosophila, the somatic cells and spermatogonia of the male contain one X-chromosome and its smaller mate the Y-chromosome, while the somatic cells and oögonia of the female have a pair of X-chromosomes. All ripe eggs are alike and contain one X-chromosome, but the spermatozoa are of two kinds, half contain one X-chromosome, the other half receive the Y-chromosome (absent in some animals). Fertilization with the first kind causes the egg to develop into a female, with the second a male is the result (see *Sex*). Here we have a definite group of characters associated with a definite chromosome.

While the segregation and mode of inheritance of independent unit characters and the determination of sex furnish evidence for the importance of chromosomes in heredity, the phenomena of *linkage,* if Morgan's hypothesis be correct, throw the newest and most important light upon the structure and behavior of the chromosomes. Bateson and Punnett obtained aberrant ratios with certain strains of sweet peas. Instead of the ratio 9:3:3:1 in these cases they found ratios like 2:1:1 and 177:15:15:49. They tried at first to explain these as due to repulsion

and coupling of factors. Later Bateson substituted the hypothesis of *reduplication*, according to which the separation of factors may take place at different times in the development of the germ cells. T. H. Morgan (1913) has found similar ratios in the fruit-flies. This species has normally red eyes. In Morgan's cultures a white-eyed male appeared.

White male × Red female

XY × XX

F_1 XY ♂ XX ♀ all red

Sperm X Y

Eggs	X	Y
X	XX ♀ red	XY ♂ red
X	XX ♀ red	XY ♂ white

1 : 2 red ♀ 1 red ♂ 1 white ♂

Mated to a red-eyed female, he produced all red-eyed offspring. When these were inbred half the males in F_2 were like the grandfather, but all the daughters were like the grandmother. We have here a *sex-linked* character, and Morgan's explanation of its inheritance is simply that the locus of its factor is in a sex-chromosome. Let **X** represent a chromosome bearing the factor for red and X one from which it is absent (white) then the mode of inheritance may be represented by the above diagram:

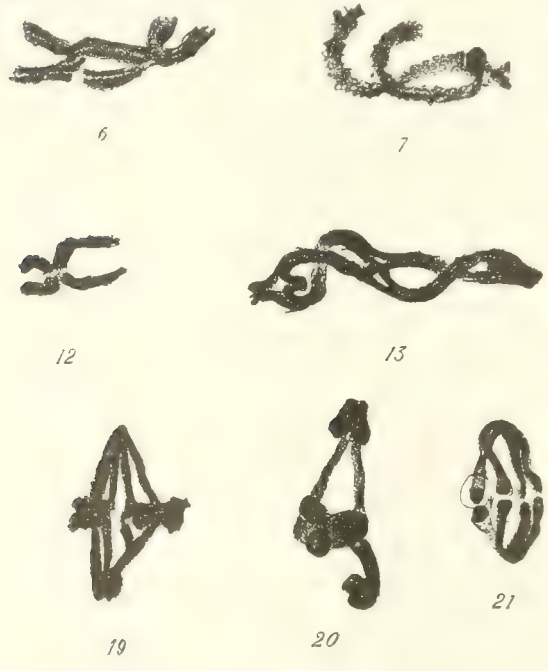


Fig. 3142.—Chromosomes in Primary Spermotocytes of Batracoseps, Showing "Crossing Over." Highly magnified and drawn with camera lucida. (After Janssens.)

It might be supposed from this that there is some relation between white eyes and maleness, but if one of the red-eyed females that is heterozygous be mated with a white-eyed male she will produce red- and white-eyed females as well as males showing both colors. The color is associated with the sex-chromosome but not with a particular sex. If one of these white-eyed females be mated with a red-eyed male the relations are reversed again and in F_1 all the females are red-eyed and all the males white, as shown by the following diagram:

Red male White female

XY ♂ XX

Sperm X Y

Eggs	X	Y
X	XX ♀ red	XY ♂ white
X	XX ♀ red	XY ♂ white

1 : 2 red ♀ 2 white ♂

When two sex-linked characters are present, if they are linked together in the same chromosome, the combination will appear in the same ratios as the single character; if they are independent, the ratio will be 4:1:1:1:1. The ratios actually obtained, however, are usually intermediate between 2:1:1 and 4:1:1:1:1, if a sufficient number of matings have been made. A gray, red-eyed female Drosophila was mated to a yellow, white-eyed male. In F_2 all the females were gray with red eyes, nearly half the males were the same, and about the same number were yellow with white eyes; but there were few that were either gray with white eyes, or yellow with red eyes, the actual numbers being as follows:

GR♀	GR♂	GW♂	YR♂	YW♂
6080	2870	36	34	2373

Morgan explains this departure from expected ratios by the hypothesis that each factor has its locus not only in a definite chromosome but also at a special place in the chromosome. Now it is known that during maturation pairs of homologous chromosomes become twisted together, and Jannsens (1909) has observed in amphibia that cross unions between the strands are sometimes present (Fig. 3142). In consequence a strand is made up of part of one chromosome and part of another, so that some chromosomes that separate in the reducing division may represent different combinations of those that united in synapsis. The departures from simple ratios may thus be due to a *crossing over* so that a pair of homologous factors change places. If factors have a linear arrangement in the chromosome (Fig. 3143), the farther apart they are, the more likely that a break will occur between them. So Morgan takes the frequency of separation as the measure of the distance apart of linked factors.

Fig. 3143—Diagrams of "Crossing-over". xxi and xxii, post-synaptic stage, xxiii, first maturation, division; xxiv, second maturation divisions. (After Janssens.)

In the male there is but one X-chromosome, and crossing over is impossible. "Breeding experiments show that no crossing over takes place for sex-linked factors in the male of Drosophila."

When three sex-linked factors are present double crossing over may occur, but this is less probable than simple crossing and experimentally has been found to be less frequent. Morgan has detected as many as twenty-five sex-linked characters in Drosophila, and his explanation of their behavior is in harmony with the facts of heredity and of the history of the germ cells, and seems to be well founded.

It should be noted that sex-linked characters are

different from *secondary sexual* characters, which are strictly *sex-limited.* The mechanism for the inheritance of this class of characters is not understood and it may be true as Morgan suggests, that it differs in different groups of animals.

Important confirmation of the chromosome theory of heredity is furnished by a preliminary communication by Bridges (1914). If a white-eyed female Drosophila be mated to a red-eyed male usually the offspring are red-eyed females and white-eyed males in equal numbers (see diagram above). But in the case discovered by Bridges about five per cent. of the females had white eyes and about the same number of males had red eyes. The explanation is the presence in this female of a supernumerary Y-chromosome. This would disturb the maturation divisions so that instead of one X-chromosome going into the polar body and one remaining in the egg, both X-chromosomes may pass into the polar body, leaving only the Y-chromosome in the egg, or the reverse; or else the Y-chromosome may accompany one X either in the egg or polar body. If each X-chromosome were recognizable we should have in this case six possible kinds of eggs, while the male produces only two kinds of spermatozoa. The results of the mating are shown in the diagram that follows:

		Red male **XY**	×	White female XXY
	Sperm	**X**		Y
	Eggs			
90%	X_1	**X**X_1♀ red		X_1Y♂ white
	X_2	**X**X_2♀ red		X_2Y♂ white
	X_1Y	**X**X_1Y♀ red		X_1YY♂ white
	X_2Y	**X**X_2Y♀ red		X_2YY♂ white
10%	X_1X_2	**X**X_1X_2♀ red		X_1X_2Y♀ white
	Y	**XY**♂ red		YY?

The white-eyed females are developed from XX eggs fertilized by Y-sperm and the red-eyed males come from the union of Y-eggs and X-sperm. These females are exact duplicates of the mother and these males are exactly like the father in all sex-linked characters, proving that the sex-linked factors are carried by the X-chromosomes. That it is the presence of a supernumerary Y-chromosome that prevents the normal *disjunction* of the X-chromosomes in this case is proved by the fact that cytological investigations have shown that about half the daughters contain a supernumerary Y-chromosome while the other half contain only the two normal X-chromosomes. This is conformed by breeding experiments, which also indicate the presence of the supernumerary Y-chromosome in half of the sons with white eyes. While the numerical proportion and some of the other results of this mating have not been explained, everything so far goes to show that the hereditary characters of the offspring may be altered by a mechanical shifting of certain chromosomes due to the accidental presence of a supernumerary one in the germ-cells of the mother.

Conclusions.—We have now completed a review of the principal fundamental conceptions to be found in theories of heredity. We have seen that the animistic theories belong to the age of mysticism, and receive no confirmation from scientific investigations. We have seen that there is reason to believe that heredity has its foundation in a physical basis, which is the protoplasm of the cell; and this may perhaps be differentiated into physiological units of some kind. Further there is much evidence from observation and experiment to show that the physical basis for heredity forms an idioplasm residing in the nucleus of the cell and more especially in those parts of the nucleus which are composed of chromatin. Whether the idioplasm of the germ cell is essentially different from that of somatic cells is doubtful. The view that such a differentiation does exist is strongly supported on morphological evidence in the single case of Ascaris. The physiological evidence is clearly against a qualitative division of the idioplasm. On the other hand, it indicates some sort of progressive differentiation in the idioplasm of somatic cells during development, a differentiation which begins earlier or later in different species. The causes of this differentiation appear to lie partly within the idioplasm itself and partly in the conditions surrounding it. Both experiment and common sense favor the view that the cell can contain no elements presenting other than purely cellular characteristics. There are as many species of germ cells as there are species of organisms. The normal offspring is similar to its normal parent, because the germinal idioplasm of the two are of common origin, and both have developed under normal conditions. There is no evidence that the germ cells in an adult organism may be affected in any direct way by any changes that may take place in the cells of the body. Therefore the inheritance of acquired modifications of somatic cells is theoretically improbable. Just how much of development is a process of epigenesis and how much is due to preformation in the germ-cells is still an open question. The facts of Mendelian inheritance indicate a high degree of preformation, and the applications of this principle have given a control over heredity that was undreamed of a few years ago.

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Hermaphrodism.—*See Teratology.*

Hermophenol, mercury phenol-disulphonate of sodium, is a white, amorphous powder soluble in five to seven parts of water. It is said to contain forty per cent. of mercury, and to be strongly bactericidal without caustic effect on the tissues. It can stand a heat of 120° C. without decomposition. Bérard used it as a disinfectant for the hands, and in three-per-cent. solution for ophthalmia neonatorum, and Reynes injected 4 c.c. (ʒ i.) of a half-per-cent. solution, every two or three days, for syphilis. W. A. Bastedo.

Hernia.—This term, possibly derived from the Greek ἔρνος (a spout), is employed to denote the protrusion of a viscus from the cavity in which it is normally contained. Although it may be used to denote the escape of organs from other cavities, yet when unqualified it signifies, as does the vulgar term "rupture," a protrusion from the abdominal cavity. As usually employed it implies a pouching of the containing wall forming a continuous sac for the displaced contents. An escape of the viscera through a wound in the wall is better termed a "protrusion." The term "internal hernia" is employed to denote either the protrusion of the abdominal contents into the thoracic cavity—*i.e. diaphragmatic hernia*—or the introsusception of the intestine into one of the peritoneal fossæ. The latter condition is, however, more properly classified as one of the forms of intestinal obstruction.

A hernia may occur at one of the openings of the abdominal wall normally present in fetal life, which has not become closed at the time of birth, and is then termed a *congenital* hernia; *i.e.* a congenital inguinal hernia is one in which the abdominal contents push their way into the unobliterated processus vaginalis. All herniæ developed subsequently to birth are termed *acquired*. They occur at the points where the abdominal wall is relatively weak. Hence arises the anatomical classification of herniæ: inguinal, femoral, umbilical, lumbar, diaphragmatic, obturator, etc.

The parts constituting a hernia are, first, the sac and, second, the contents. The sac consists of peritoneum continuous with the parietal peritoneum of the abdominal cavity. The coverings of the sac vary with the anatomical variety of the hernia, and are as a rule fascial with the exception of the skin. The shape of the sac depends upon the nature of the opening in the abdominal wall and the degree of restraint afforded by the fascial coverings. If the opening be circular with more or less sharp margins the sac as a rule is globular, as in umbilical and femoral herniæ.

In inguinal hernia the sac is elongated, owing to the fact that the fascial coverings are tubular. If the hernia is incomplete the sac is sausage-shaped. On the other hand, it is pyriform in shape when the hernia becomes scrotal. Bands of the investing fascia may constrict the sac in such a manner as to produce hour-glass forms; or from the same cause diverticula may result, the restraint being unequally exerted. The parts of a sac are termed the mouth, the neck, and the fundus or body. The contents of the sac usually consist of small intestine or omentum, or both; more rarely they consist of the colon, cecum, or appendix, sigmoid flexure, bladder, or uterine adnexa. When the contents consist of intestine alone the hernia is called an enterocele; when of omentum alone an epiplocele; when of both, an enteroepiplocele. Fluid may be found in the sac either free or encysted by adhesions—*hydrocele of the hernial sac.*

Etiology.—Causes predisposing to hernia are:

1. *Heredity.*—Weaknesses in the abdominal wall predisposing to hernia are undoubtedly inherited. Macready[1] estimates that twenty-five per cent. of patients with hernia give an ancestral history.

2. *Sex.*—About six males suffer from hernia to one female. This is to be explained both by the much greater frequency of inguinal hernia in males, due to the necessary enlargement of the inguinal canal, and by the nature of their occupation.

3. *Age.*—Except in the period of infancy, when the influence of congenital weakness upon the development of hernia is most marked, the greater number of herniæ occur in the active period of life, between fifteen and fifty.

4. *Elongation of the Mesentery,* although generally given as an etiological factor in the production of hernia, is rather a concomitant result—with hernia—of causes such as weakness and laxity of the abdominal wall.

Exciting Causes of Hernia are: 1. Occupations necessitating violent muscular efforts. 2. Strains, as lifting, coughing, sneezing, and parturition. 3. Conditions producing stretching of the abdominal wall, as pregnancy, ascites, obesity. 4. Atrophic changes, as senility. 5. Traumatism resulting in the replacement of normal by cicatricial tissue, or in the destruction of nerves, thus causing paralysis and atrophy of muscle.

Clinical Varieties of Hernia.

The clinical classification of herniæ is based upon the condition of the contents and the relation of the contents to the sac. Thus we have: (*a*) Reducible; (*b*) irreducible; (*c*) inflamed; (*d*) obstructed; and (*e*) strangulated herniæ.

Reducible Hernia.—A reducible hernia is one in which the entire contents can be wholly reduced to the abdominal cavity, without recourse to a cutting operation. Reduction is often effected by posture, but may be accomplished only by taxis. It is the most common class of hernia.

Symptoms.—The earliest subjective symptom in an acquired hernia is usually pain (ninety per cent. of cases). In a hernia caused by a strain the pain may be sharp and accompanied by a sense of something giving way. Usually it is dull and dragging and, after a varying period of time, is replaced by a sense of fulness which is marked on standing or straining and disappears in the reclining position. Large herniæ are not infrequently accompanied by gastric or intestinal symptoms, which are probably reflex in character.

The objective symptoms depend upon the size of

the hernia and the nature of its contents. A small hernia exhibits a tumor as a rule only on standing or coughing and the latter disappears when the patient lies down. A large hernia is often not spontaneously reducible; but it increases in size in the erect position or on coughing, and if inguinal it may then be seen to descend into the scrotum or labium.

In both small and large herniæ a characteristic impulse is felt on coughing. In an enterocele there may be a gurgling felt or heard either at the moment when the bowel descends into the sac or on reduction of the hernia, and at the same time the tumor is more or less tympanitic. An epiplocele is dull or flat and feels more irregular and does not give so marked an impulse.

Diagnosis.—See Anatomical Varieties.

Treatment.—For taxis, see Strangulated Hernia. For operative and mechanical measures, see under Anatomical Varieties; also under Mechanical Treatment.

Irreducible Hernia.—This term is applied to a hernia in which the contents, although practically normal in condition, cannot be wholly returned to the abdominal cavity. The chief causes of irreducibility are, first, adhesions of omentum to the sac or between the contents, or thickening of the imprisoned omentum (according to Macready the contents consist of omentum in ninety per cent. of cases); secondly, the formation of part of the sac by the gut itself (more fully described under cecal and sigmoid herniæ); and, thirdly, the bulk of the hernia may be so great that the contents cannot be received into the abdominal cavity.

Irreducible hernia is more frequently observed in middle life and in the umbilical variety. It is uncommon in children. It may be permanent or transitory.

Symptoms.—The symptoms depend upon whether the hernia is large or small and upon the nature of the contents. Small epiploceles usually give no especial symptoms, while larger ones, from dragging upon the omentum, are liable to cause digestive disturbances and are prone to inflammation. In irreducible enterocele the condition is more serious. The imprisoned bowel is apt to become obstructed, which condition may be evanescent or may persist, and furthermore strangulation may supervene. Hence the symptoms vary from occasional attacks of colicky pain and flatulence, with more or less constipation, to those of complete obstruction and strangulation.

Treatment.—Herniæ which have only recently become irreducible are, as a rule, more or less inflamed or at least congested; so that, if immediate operation is not feasible, rest in bed and the application of cold with moderate pressure are indicated. Prolonged efforts at reduction under such circumstances are more than likely to aggravate the condition, and hence considerable judgment has to be exercised in the employment of taxis. In old cases or those in which the above treatment does not suffice, operation should be performed. The contraindications to operation do not exist to the same extent as in reducible hernia, since the condition *per se* is more dangerous. In cases in which operation is distinctly contraindicated, as in the aged or diseased, or in which the hernia is so large that the return of the contents to the abdomen would not be possible, the employment of some device for supporting the hernia and preventing its increase is indicated.

For umbilical hernia some form of abdominal support is useful. In large scrotal herniæ a stout canvas bag, supported from the shoulders, has been found advantageous.

The employment of special trusses, as the "hinged-cup truss" for inguinal hernia, can be recommended only when operation is out of the question, although Macready claims sixty-eight per cent. of reductions by its use. But even then a cure of the hernia is seldom attained.

Inflamed Hernia. When a local peritonitis occurs in the hernial sac the hernia is said to be inflamed. An inflamed hernia is nearly always caused by obstruction to the circulation of imprisoned omentum, and practically differs from a strangulated hernia in that the omentum instead of the intestine is affected. It may be the result of trauma, either from a truss or from prolonged taxis, and it may possibly occur from obstruction of the bowel or enteritis. A strangulated hernia always becomes inflamed if the condition persists for any length of time. Irreducible herniæ are most prone to inflammation, especially the femoral and umbilical varieties. The process results in the production of lymph and fresh adhesions. The sac may become distended with fluid, and obstruction and strangulation may supervene.

Symptoms.—A sense of increased fulness, pain, and tenderness are present. There is usually a slight rise of temperature. There may be vomiting and constipation. If obstruction or strangulation occurs the symptoms of this condition supervene. On palpation there are tenderness and local heat, and the mass may be tense or semifluctuating. Inflamed omentum usually feels hard and nodular.

Treatment.—All inflamed herniæ should be operated upon at once. Delay is not permissible unless grave contraindications to operation are present. It is impossible to distinguish between a partial strangulation of the intestine (Richter's hernia) and simple inflammation. Enemata, but not cathartics, should be used. The pain should not be relieved by anodynes.

Obstructed Hernia.—An obstructed or incarcerated hernia is one in which the passage of the contents of the intestine is inhibited, but in which the circulation of blood is not interfered with.

Obstruction is more common in irreducible than in reducible herniæ. As it is usually due to constipation, it occurs more often in herniæ containing the large intestine. Hence we find it more often in umbilical herniæ and in large inguinal herniæ in which the contents are the sigmoid flexure or cecum. As large herniæ are more common and as there is a lack of intestinal tone in the elderly, obstruction occurs most frequently during the period from middle life on.

The determining causes are usually neglected constipation, and the ingestion of indigestible food or food that leaves a large residue.

Symptoms.—The symptoms vary considerably, but are distinguished from those of strangulation by their gradual development. Constipation at first is not generally absolute. The tongue is coated, the breath is foul, and there is complete anorexia followed by vomiting, which is not usually peristent and seldom stercoraceous. There is colicky pain which may be severe, but there is no collapse. Distention is more or less marked. The hernia, if before reducible, becomes irreducible and increases in size. Impulse, however, is obtainable, which serves to eliminate strangulation. The tumor is often doughy and may be dull on percussion, although imprisoned gas may give a tympanitic note. The prognosis is usually good.

Treatment.—The emptying of the bowel is the first consideration, and this should be accomplished by high enemata and by massage of the hernia. Cathartics should not be given until the tumor has decreased in size.

If there be no response to treatment, and if strangulation be suspected, operative interference should be at once instituted, as delay may be fatal. Recurrence of obstruction may be to a large degree averted by proper attention to the food and bowels.

Strangulated Hernia.—A strangulated hernia is one containing intestine in which both the passage of bowel contents and the circulation of blood are

interfered with. For the time being it is not spontaneously reducible.

This condition is rare in infancy and is most common in middle life and old age. It occurs more often in small than in large, and in old than in recent herniæ; although sometimes a hernia may become strangulated on its first appearance. Narrowness and shortness of the neck of the sac conduce to it. Hence it is more common in femoral than in other varieties, and in irreducible herniæ when the neck is partially occluded by adherent omentum, as in some umbilical herniæ. According to Berger, the risk of an inguinal hernia undergoing accident is 2.16 per cent., of a femoral 9.02 per cent.

Determining Causes.—Among the more common causes may be mentioned straining, such as occurs in lifting, sneezing, coughing, etc., in all of which acts there is an increase in the intra-abdominal pressure. Consequently all conditions predisposing to such strain, as certain occupations, pulmonary disease, constipation, and obstruction to urination, are all predisposing causes. Trauma from ill-applied trusses, inflammation, and bands in the sac all may produce it. Volvulus of the contained loop may occur.

Mechanism.—Several theories have been advanced as to the manner in which the pressure is brought about and exerted upon the contained bowel. Undoubtedly the exact mechanism varies in different cases, and it is a combination of factors rather than any single one that produces the result. Among the various theories advanced, the following are the more important: 1. Elasticity of the ring (Richter). 2. Compression of the efferent by the distended afferent end of the loop (Lossen). 3. Angulation of the distal end at the margin of the orifice (Scarpa). 4. Fecal impaction. 5. Torsion or volvulus of the loop (de Roubai). Whatever the cause it must first interfere with the return circulation, producing congestion which increases the bulk of the contained gut and thus augments the pressure. The condition thus tends always to increase itself.

Violent peristaltic efforts of the intestine to force its contents onward increase the pressure at the point of constriction. The mesentery becomes swollen with the intestine and at the same time is put upon the stretch by the excessive peristalsis. This stretching of the mesentery may produce interference with the circulation in the mesentery and gut on the abdominal side of the constriction, which accounts for the not infrequent circulatory disturbances observed proximal to the site of constriction. The latter may also be due to the nipping of the mesenteric vessels supplying gut which is not in the hernial sac. Thrombosis of the mesenteric vessel may be caused and may extend to vessels without the area of constriction. Furthermore, volvulus of intestine lying in the abdominal cavity may be caused by the anchoring of a loop in the hernial sac. The intestine in the sac then represents only a portion of that involved. In *retrograde hernia* (*vide infra*) the gangrenous loop lies wholly in the abdomen.

Anatomical Changes.—The strangulated intestine passes through stages which can be conveniently stated as (1) congestion; (2) inflammation; (3) gangrene. The rapidity of sequence of these stages depends upon the degree to which the circulation is interfered with. As the return circulation is the first to be interfered with, the first change is an engorgement of the vessels. The walls of the intestine become edematous and change in color, becoming dark red or purple, and black or grayish-black as gangrene supervenes.

The peritoneum loses its glistening appearance and becomes dull and granular as its vitality disappears. At the site of constriction, usually the neck of the sac, there is a deep furrow which is as a rule grayish in color. The intestine becomes cold, loses its power of contractility, and is distended with gas. As these changes progress there is a transudate of serum, later of blood, into the sac; and a migration of pathogenic germs, notably the *B. coli communis* and varieties of streptococci and staphylococci, takes place through the walls of the gut. The local peritonitis in the sac may extend to the general cavity and produce a spreading peritonitis, or it may be shut off by adhesions. On the other hand, if the vitality of the bowel within the abdomen be impaired, from the causes already stated or from a progressive thrombosis of the vessels, peritonitis may be primarily instituted within the abdomen itself. If the strangulation be due to inflammation of an irreducible hernia, the sequence of events is slightly changed in that the stage of inflammation precedes that of congestion. When gangrene ensues it may occur locally in small patches at the seat of constriction or at the convexity of the loop, or the whole loop may slough. With the gangrene there is an escape of the contents of the bowel. The skin over the sac at first is not involved, but later the tissues covering the sac become infiltrated and edematous. Finally, an abscess may form and burst and a spontaneous artificial anus result. This is more likely to be the outcome in cases of partial enterocele (Richter's hernia), when only a portion of the circumference of the gut is nipped, and explains the manner in which spontaneous cures may sometimes occur.

The extent of gangrene varies from a portion of the circumference of the bowel to several feet.

The period elapsing between the onset of strangulation and the occurrence of gangrene varies considerably, from four hours to several days, but is rarely less than twenty-four hours. The presence of omentum in the sac delays the onset of gangrene.

Symptoms.—The symptoms of a strangulated hernia are conveniently divided into the general and the local. The general symptoms are those of strangulation ileus in contradistinction to those of an obstructed hernia, which are rather those of obturation ileus. They are pain, vomiting, complete constipation, and collapse. To these may be added those of peritonitis.

Pain is of two varieties: a severe colicky pain caused by violent peristalsis and felt in the region of the umbilicus, which may be constant but more often remittent, and an aching pain at the hernial site. After the onset of gangrene the peristaltic pain usually ceases.

Vomiting is an important and characteristic symptom. Two distinct phases of vomiting are usually observed. The first is reflex in character and is apparently a result of the violent peristalsis set up by the compression of the gut and mesentery. It is concomitant with the initial colicky pain, is repeated frequently and the vomitus consists of the stomach contents only or possibly those of the first portion of the duodenum in addition. It is more severe the higher the obstruction and may even be absent in strangulation of the colon. The second phase of vomiting is due to the obstruction and is caused by the damming back of the contents of the intestine producing overdistention of the stomach and intestine. The vomitus now consists of intestinal contents and is copious. Large amounts may be ejected at a time or, as usually observed, there are frequent eructations of small quantities.

The initial reflex vomiting together with the peristaltic pain ceases with the advent of gangrene and there is often an appreciable interval between it and the obstruction vomiting, its length depending upon the site of strangulation; the obstruction vomiting being later but more copious in low obstructions. In Richter's hernia, there being no obstruction, only the initial reflex vomiting occurs.

Constipation is complete, no gas or feces being passed. However, the bowel may be emptied below the seat of strangulation, and if the strangulation is high up in the small intestine a considerable

quantity of feces may be expelled. Also in Richter's hernia, constipation is not the rule and there may even be diarrhea. The degree of abdominal distention is likewise dependent upon the site of strangulation. If this is located high up in the small intestine it is relatively slight and is epigastric in character—acute distention of the stomach, while if the large intestine is implicated it is great. Excessive peristalsis is present until the intestine becomes paralyzed by overdistention.

In patients with thin abdominal parieties the peristaltic contractions may be seen and felt; and in all cases are evident to the ear.

Collapse is usually profound, although it may be delayed for several hours. The pulse becomes weak and thready, the temperature is subnormal, the extremities are cold and moist, and the facies abdominalis is marked. When inflammation sets in, the temperature usually rises, but it seldom reaches a high level. The duration of life averages from five to seven days. In the aged the symptoms often are not marked, the course presenting an asthenic type in which some of the classic symptoms may be wholly absent. The symptoms at the site of the hernia are pain, irreducibility, loss of impulse, tenderness, dulness, and the absence of gurgling. The hernial protrusion may be so small as readily to escape notice, and it must be remembered that the absence of a history of hernia does not exclude, inasmuch as a hernia may become strangulated on its first appearance. The attention of the patient is usually attracted to the hernia by the presence of pain. The local pain may be masked, however, by the general abdominal pains.

The chief value of irreducibility as a sign of strangulation is in herniæ that have previously been reducible. It may be absolute or relative. Tenseness, dulness, loss of impulse, and the absence of gurgling are all due to the same causes, *i.e.* fixation and swelling of the contents of the sac and the exudation of fluid within it.

In certain forms of strangulated hernia the characteristic symptoms may be masked or modified.

The following classification, slightly modified from that of Eccles,[2] will serve to indicate the sources of ambiguity.

I. Cases in which the peculiarities are dependent upon the contents of the sac.

1. Strangulation of a portion of the bowel.

(1) Partial enterocele (Richter's hernia).

(2) Strangulation of the vermiform appendix.

(3) Strangulation of Meckel's diverticulum (Littré's hernia).

2. Strangulation within the body of the sac.

(1) By bands, adhesions, apertures in omentum, etc.

(2) By kinking or volvulus.

II. Cases in which the peculiarities are dependent upon the sac.

1. Strangulation within a loculus or pouch of the sac.

III. Retrograde incarceration or hernia "en W."

In cases of strangulation of a portion of the bowel symptoms of obstruction are usually absent while the local signs may be characteristic. In the cases where only a portion of the contents of a hernia are strangulated the remainder may be reducible.

Retrograde incarcerated hernia, or hernia "en W" was first described by Lanenstein[2] in 1894, and has been recently reviewed and the literature brought to date by Friedman.[3] It derives its name of W-hernia or hernia "en W" from the fact that the two lateral loops, in which the circulation is normal or only slightly impaired, lie in the sac while the middle connecting loop lies in the abdomen and is gangrenous, its mesentery being constricted at the neck of the hernial sac.

In the following groups of cases errors of diagnosis as to the site of strangulation, or as to whether it is present or not, may arise (modified from Eccles[4]).

I. Cases of multiple herniæ.

1. Two (or more) herniæ, one irreducible and the other strangulated.

2. Two herniæ, one concealing the other.

3. An inguinal and a femoral hernia on the same side, one strangulated and the other not.

II. Cases of irreducible hernia in which the obstruction or strangulation is within the abdomen and not at the site of the hernia.

In cases of multiple herniæ the local symptoms as a rule are sufficient to determine the site of strangulation. In infants, inasmuch as they are unable to direct attention to the local condition and as they are frequently subject to attacks of vomiting and colic, the diagnosis may be delayed. In them continued vomiting should lead to a thorough examination of all hernial sites. The differential diagnosis lies chiefly between strangulated and obstructed or inflamed hernia. Other conditions which may simulate strangulated hernia are inguinal adenitis, acute epididymitis or orchitis, and severe colic, peritonitis, or the uncontrollable vomiting of pregnancy in conjunction with a hernia.

Prognosis.—The prognosis in untreated cases is uniformly bad, with the exception of the exceedingly few cases that end in recovery with the spontaneous formation of an aritificial anus. The mortality following taxis and that associated with herniotomy manifestly cannot be compared, inasmuch as the conditions found in many cases successfully operated upon would absolutely contraindicate the employment of taxis, and also because cases in which taxis proves successful would in all probability be successfully treated by operation.

The statistics of Frickhoffer[1] in regard to cases in which taxis has been apparently successful give in 308 cases of femoral hernia a mortality of 14.9 per cent., and in 518 cases of inguinal hernia one of 7.8 per cent. The statistics of herniotomy show a mortality that varies from 10 per cent. to 12 per cent. in cases in which the strangulation has existed twenty-four hours or less, to 50 per cent. in cases in which it has existed over three days. The risk of herniotomy when the gut is still returnable is comparatively slight. In gangrenous hernia the mortality depends largely upon the method of treatment of the intestine (see Treatment).

In a total of 354 cases of gangrenous hernia, collected up to 1900,[5] 120 were fatal, a mortality of 34 per cent. Of these 354 cases, 96 were of the inguinal variety, with 25 deaths (mortality, 26 per cent.); 188 were of the femoral variety, with 69 deaths (mortality, 37 per cent.); 22 were of the umbilical and 2 of the ventral variety, with 16 deaths (mortality, 67 per cent.); and 7 belonged to the obturator variety, with 6 deaths (mortality, 86 per cent.). By these statistics it will be seen that the mortality of femoral hernia is greater than that of the inguinal form, and the mortality of umbilical hernia is greater than that of the femoral hernia. A compilation of the cases operated upon since 1900 would probably show a decrease in the mortality to nearly half of the above figures, but this relative mortality would probably remain the same.

Treatment.—The treatment of strangulated hernia is by means either of *taxis* or of *herniotomy*.

Taxis is the reduction of the protrusion by manipulation. It is best performed with the aid of a general anesthetic, and the operator should be prepared to resort at once to herniotomy if his efforts at reduction fail. In inguinal and femoral hernia the parts are relaxed by flexing the thigh on the pelvis and rotating it in an inward direction. Placing the patient in a position of slight inversion, *i.e.* with the head lower than the pelvis, is permissible.

The neck of the sac is then grasped with the left hand and gentle efforts are made with the right hand to press the contents back. Pressure should be

exerted in the direction of the canal; upward, outward, and backward in inguinal and backward and upward in femoral hernia. The efforts should never be prolonged for more than five minutes and roughness is distinctly contraindicated.

Success is determined by the complete disappearance of the hernia, and by the fact that the surgeon can pass his finger through the ring.

It must be borne in mind that in the case of a hernia "en W" reduction of the coils in the sac may not help the gangrenous intervening loop which lies in the abdomen.

Taxis should not be attempted when an immediate operation is possible; is not contraindicated by the age or condition of the patient; but is absolutely contraindicated in the following conditions:

1. When it has already failed
2. When the superficial tissues are inflamed.
3. When there is reason to suppose that the intestine may be gangrenous.
4. When strangulation has existed for twenty-four hours.
5. When the hernia has been previously irreducible.
6. When there is great prostration.

The dangers of taxis are:

1. Injury or rupture of the intestine.
2. The return of gangrenous intestine to the abdominal cavity.
3. The transference of septic fluid from the sac into the general peritoneal cavity.
4. "Reduction *en masse*."

Reduction *en masse* is rare, occurring, according to Comer and Howitt[6] is 0.3 per cent. of reduction of strangulated hernia. It is more frequent in inguinal hernia, and is practically the conversion of the hernia into a form of interstitial hernia; the sac and its contents being forced into a position between the transversalis fascia and the remainder of the abdominal wall, while the constriction still remains at the neck (Fig. 3144). The sac may be ruptured and its contents escape into its new position; or only part of the sac may be reduced.

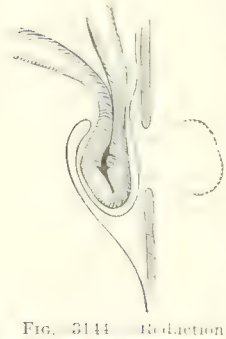


Fig. 3144.—Reduction en Masse without Relief of the Constriction.

Herniotomy and *kelotomy* are the terms applied to the operation for the relief of strangulated hernia. This operation possesses the advantage over taxis of avoiding its dangers, of permitting inspection of the intestine, and of affording an opportunity for the radical cure of the hernia.

The steps in the operation are: (1) The exposure of the sac. (2) Opening of the sac and relief of the constriction. (3) Treatment of the contents. (4) Closure of the wound.

The sac is exposed by an incision similar to that which would be employed in an operation for radical cure. The incision should be made in such a manner as to expose well the neck of the sac, and it may have to be prolonged in order to afford room for resection of the bowel. The sac is recognized by its dark color and its gliding over the contents. It is opened by pinching it up with forceps so as to form a fold which can be incised without injury to the contents. When an opening has been made, the fluid which escapes will be clear and odorless, although it may be bloody, if the gut is sound; or it will be cloudy, or purulent, if the vitality of the gut has become impaired. The interior of the sac and the contents are then thoroughly washed with saline solution to lessen the chances of contamination and the constriction is sought for and divided.

Inasmuch as the constriction is usually caused by bands of fascia which lie outside the sac, division is best done from without, and not from within, as was formerly taught by the old school. It may be necessary, however, in some femoral herniæ to divide it from within, which is done by cutting upward with the herniotome or blunt-pointed bistoury or by use of a director. The constriction having been freely divided the gut must be gently drawn out to expose the efferent and afferent portions, especially the latter, in order to observe their condition, since changes in in their nutrition may have occurred for a considerable distance within the abdomen. If the condition of the gut is satisfactory it is returned to the abdomen and the wound is closed as in the operation for radical cure of a hernia of the same variety.

The gut is returned if its peritoneal coat is smooth and glistening, if its color is not black or gray, even though it may be dark red or purple, and especially if it has retained the power of contractility in all its parts. It must not be returned if the peritoneum has a granular aspect, if the fluid in the sac is cloudy and foul, or if the gut is cold and flabby and has lost its contractility. If there is doubt, the constriction having been freely relieved, the bowel may be surrounded with compresses wet in warm decinormal salt solution, for several minutes, and its condition again noted. In strangulated femoral hernia it has been the practice of the writer, after having opened the sac, if the condition of the intestine was found bad or dubious, to make another incision through the rectus and having reduced the bowel into the abdomen to observe it then while repairing the femoral canal, and then resect if necessary by means of the additional incision. In this way the femoral opening in not weakened by enlarging it and resection can be more easily carried out through the larger and more advantageously placed incision through the rectus muscle. In cases of exceptional doubt it may be thus left for twenty-four hours. Very small areas of gangrene may be inverted, but usually resection is more practicable particularly in the small intestine.

If the gut is not in a returnable condition, there are two methods of treatment applicable: 1. Resection and immediate reunion. 2. Formation of an artificial anus. In the performance of the latter the gut is either fixed by a few sutures to the margins of the wound and opened to relieve the obstruction, or it is resected and the ends are sutured to the wound.

In the choice between resection and immediate reunion, and the formation of an artificial anus, the operator must take into consideration the condition of the patient, the site of the strangulation, and his own skill as an intestinal surgeon. According to Hofmeister,[3] the decision to form an artificial anus is tantamount to the expression that the case is otherwise hopeless.

As the following statistics in regard to gangrenous hernia show, the treatment by primary resection and immediate reunion is the most successful.

Compiler or operator	Artificial anus.			Primary resection and reunion.		
	Cases.	Deaths.	Mortality, per cent.	Cases.	Deaths.	Mortality, per cent.
Zeidler[1] (1892)	287	213	74.22	289	142	49.13
Mikulicz[2]	94	72	76.6	68	32	47.1
Hofmeister[6] (1900)	167	101	60.5	214	99	46.0
Petersen (up to 1898)	17	10	57.0	16	8	50.0
Petersen (since 1898)	5	5	100.0	12	1	8.3
Petersen[7] (total)	22	15	68.2	28	9	32.14
Gibson[5] (1900)	101	53	52.5	226	58	26.0

Of these series Gibson's are the most comprehensive and argue strongly in favor of resection and reunion. His statistics in regard to the formation of an artificial anus with and without resection of the gangrenous intestine show a very slight advantage in favor of resection. In twenty cases collected by him in which the gangrenous portion was invaginated, three patients died—a mortality of fourteen per cent.

The large mortality following the formation of an artificial anus is due not only to the immediate condition, but also to asthenia if the anus is situated high up in the tract, and to the subsequent measures taken to cure the artificial anus. In strangulations of the small intestine resection and reunion should kinking; the emptying of the intestine so far as possible; wide resection, the amount removed depending largely on the condition of the mucous membrane; drainage of the wound when peritonitis is present, or if the condition of the returned bowel is still suspicious.

For the technique of intestinal resection the reader is referred to the article on *Intestinal Surgery*. A fatal outcome in herniotomy is due to one or more of the following causes: 1. Shock. 2. Return of damaged intestine (insufficient resection). 3. Extension of an existing peritonitis, or one due to leakage (faulty suture). 4. Kinking or twisting of the returned loop. 5. Exhaustion (artificial anus)

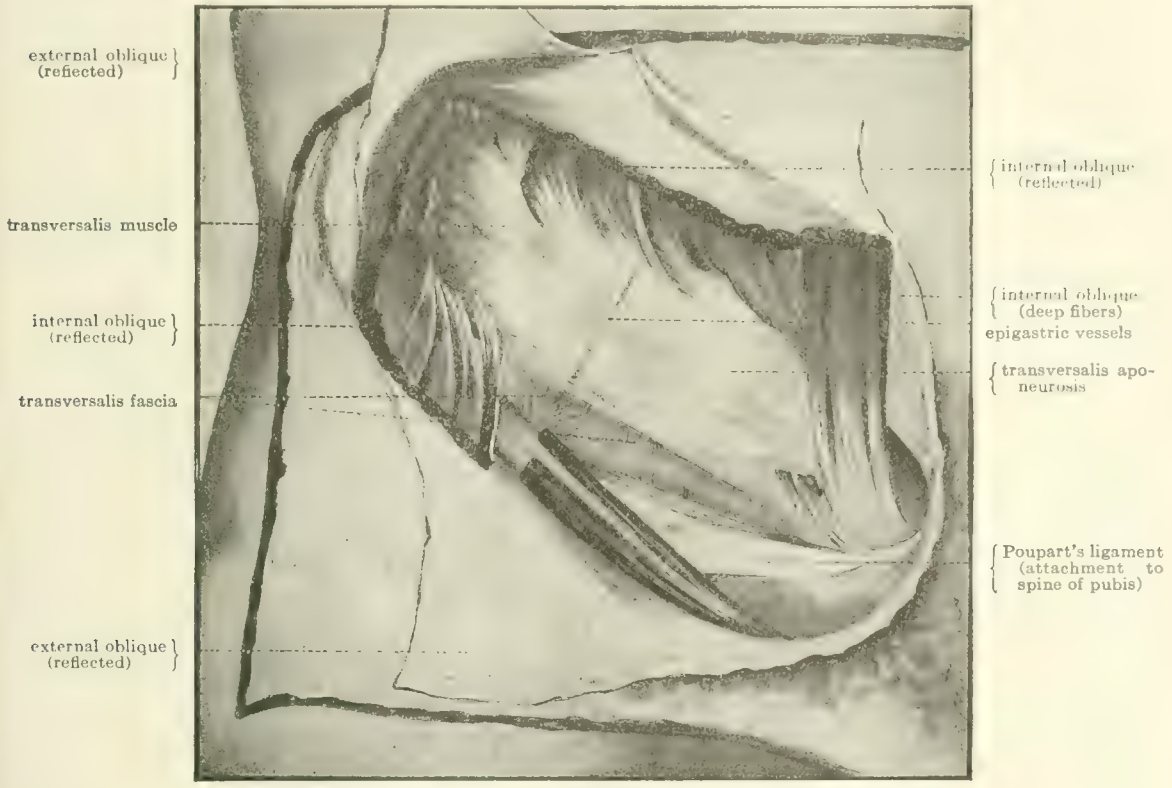


Fig. 3145.—Structures of the Abdominal Wall in the Inguinal Region.

always be done even if an opening (lateral enterostomy) has to be made in the oral limb to empty the gut. This later can be done by inserting a catheter. On the other hand in strangulation of the large intestine it is often better policy to draw the strangulated area out of the abdominal wound making an artificial anus to be closed later.

The danger of resection and immediate union of the divided ends is, with skillful operators, not so much from prolongation of the operation as from postoperative ileus. As practised by the author an end to side anastomosis may be made bringing the free end into the wound. If possible the end of the oral limb should be anastomosed to the side of the aboral limb, thus avoiding in the case of the small intestine the dangers of asthenia (starvation). (*Vide infra.*)

The chief considerations to be observed in regard to the treatment of gangrenous hernia are: the use of local anesthesia if feasible; the employment of a large wound (hernio-laparotomy), enabling the operator to return the intestine easily and visibly, thus avoiding

The after-treatment does not differ from that employed after other operations upon the intestinal tract.

Anatomical Varieties of Hernia.

Inguinal Hernia.—This term includes all herniæ into or through the inguinal canal.

Anatomy.—For the detailed anatomy of this region the reader is referred to the article *Abdomen, Surgical Anatomy of the*. There are, however, certain considerations which are not generally made clear, and which have considerable bearing especially upon the methods of radical cure. In the second month of fetal life a process, the *processus vaginalis peritonei*, is found evaginated from the peritoneum of the body cavity and accompanying the gubernaculum to that part of the skin of the inguinal region which becomes the scrotum in the male and the labium majus in the female.

Later in the male the testicle descends alongside of this process to the scrotum, and the distal portion of the process forms the *tunica vaginalis testis*. The

proximal portion ordinarily becomes obliterated, but if it remains open the tunica vaginalis continues in communication with the peritoneum, and a portion of the abdominal contents may descend through it. Such a protrusion is known as a congenital or funicular hernia, even if it does not descend until adult life. If the process remains open in the female it is known as the canal of Nuck.

Incomplete or partial obliteration of the process gives rise to cystic swellings, known as hydroceles of the cord or of the round ligaments, as may be.

The abdominal wall in this region, omitting the superficial structures, consists of the following muscular and aponeurotic layers from without in: the

3146), which is developed in curving fibers on its mesal and caudal aspect, forming the inguinal ligaments of Henle. It lies thus about half-way between the anterior superior spine of the ilium and the spine of the pubis, and a finger's breadth above Poupart's ligament. The deep epigastric artery passes upward at the mesal border of the ring between the transversalis fascia and the peritoneum. The external ring lies just above and laterad to the spine of the pubis.

The inguinal canal is about 3.5 centimeters long and is slightly longer in the female than in the male. At its commencement its ventral wall is formed by the thick fleshy fibers of the internal oblique and the transversalis muscles, and its dorsal wall by the trans-

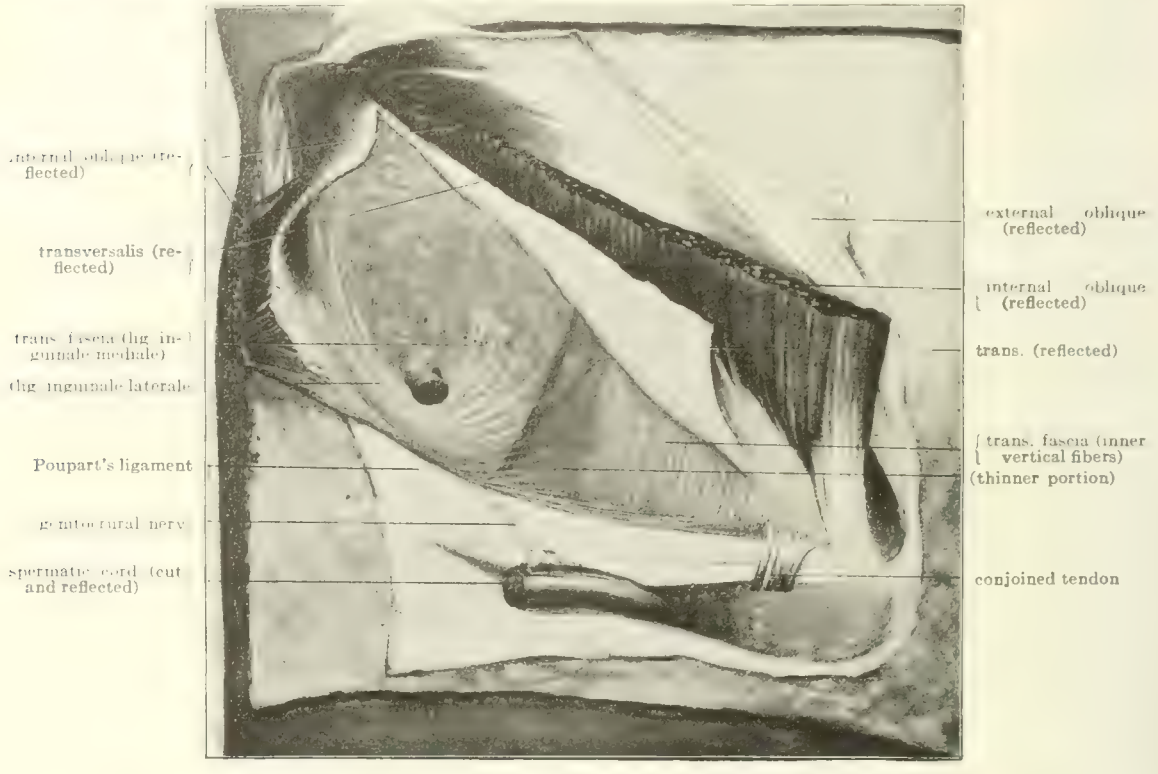


FIG. 3146.—Structures of the Abdominal Wall in the Inguinal Region.

aponeurosis of the external oblique, the internal oblique, and transversalis muscles, and the transversalis fascia. At the mesal part of this region the rectus abdominis is inserted into the pubis on a plane dorsad to the structures enumerated, with the exception of the transversalis fascia, which sends a prolongation over the dorsal surface of the muscle.

The general arrangement of these structures is shown in the accompanying figures (Figs. 3145 and 3146). The inguinal canal, which contains the gubernaculum and processus vaginalis peritonei in the fetus and the spermatic cord or round ligament in the adult, and through which the testicle passes in its descent, is found between these structures. Its commencement, the internal abdominal ring, is an aperture in the transversalis fascia normally just large enough to permit the passage of the cord. Its termination, the external abdominal ring is a slit-like aperture in the aponeurosis of the external oblique muscle. The internal ring is situated about 4 centimeters laterad to the spine of the pubis and about 1 to 1.5 centimeters above Poupart's ligament, being suspended as it were in the transversalis fascia (Fig.

versalis fascia. At about its middle its dorsal wall is still the transversalis fascia, but the internal oblique and transversalis muscles are above it and its ventral wall is formed by the aponeurosis of the external oblique. At its termination it escapes through the external oblique, and its dorsal wall is here formed by transversalis fascia, which for the last centimeter is strengthened by the conjoined tendon and the triangular ligament. In the final two-thirds of its course its floor is formed by the shelf of Poupart's as it broadens into Gimbernat's ligament. The greater part of the dorsal wall is thus seen to be formed by the transversalis fascia, and the importance of this as a safeguard cannot be overestimated. It is in fact a special development of the transversalis fascia, and by some it has been described as a part of the conjoined tendon, although it is entirely distinct from this structure. Its mesal portion consists of strong vertical fibers, its lateral of the fibers before mentioned as curving about the internal ring. Between these stronger portions is a weaker one, lying as a rule on the mesal side of the deep epigastric artery, and at this part direct inguinal herniæ occur

(Fig. 3146). The transversalis muscle is very poorly developed in this region, and consists chiefly of an aponeurosis, the fibers of which pass horizontally across to their insertion in the ventral rectus sheath, and as a rule are wanting for some distance above Poupart's ligament (Fig. 3145). The internal oblique muscle, on the other hand, consists of a thick, fleshy mass of fibers which, unless displaced by a hernia or ill developed, completely protect the internal ring and pass to their insertion with a general direction parallel to Poupart's ligament, only rising sufficiently to allow the cord to pass below them. The internal oblique in fact is the most important muscular structure safeguarding the potential weakness of the inguinal region, and the tendency toward hernia in an individual depends chiefly upon the development of this muscle and its relation to the other structures, especially Poupart's ligament. Its lower fibers arise from the lateral half of Poupart's ligament and pass horizontally to their insertion in front of the rectus abdominis. If Poupart's ligament takes a horizontal direction, as in the female, the internal oblique coincides with it and there is consequently a strong inguinal region, but if, as in some males with a deep and narrow pelvis, Poupart's ligament takes a more vertical course, there is then an unprotected triangular space bounded cephalad by the internal oblique, mesad by the margin of the rectus, and caudad by Poupart's ligament, which may be called the undefended space and through which hernia is apt to occur, especially the direct variety when the structures become relaxed from age. The conjoined tendon consists of a few fasciculi derived from the opposed surfaces of the internal oblique and transversalis muscles, and passes on the deep surface of the former muscle to be inserted by tendinous fibers to the crest and iliopectineal line. This structure is wholly concealed by the internal oblique, and its insertion seldom extends for more than a centimeter laterad to the spine of the pubis.[7] Although given considerable prominence in most textbooks, it is a negligible factor in procedures for the radical cure of hernia.

An oblique inguinal hernia is enclosed in the same layers of fascia as the spermatic cord. These layers from within out are: the infundibuliform fascia derived from the transversalis fascia; the cremasteric fascia and muscle derived from the internal oblique; and the intercolumnar fascia derived from the external oblique. These layers must be divided in separating the sac from the cord. The fascial coverings of a direct hernia are the same, with the exception that the transversalis fascia itself is substituted for its infundibuliform process.

The relations of the spermatic cord to the sac are important. The structures of the cord are usually somewhat spread out on the surface of the hernia unless the latter is small or a direct one. The vessels lie on the lateral and the vas deferens on the laterodorsal aspect of the sac. In a direct hernia the entire cord is on the lateral aspect of the sac. In congenital hernia the cord is more closely adherent to the sac than in acquired herniæ. The importance of the peritoneal fossæ on the internal abdominal wall as etiological factors in the production of hernia seems to the writer to be exaggerated. The presence of muscular or fascial weaknesses or dimples is of far greater importance, inasmuch as the peritoneum is a highly elastic and distensible membrane, and when unsupported by other structures offers little resistance to pressure from within. For the same reason the treatment of the neck of the sac is of minor importance in the operation for radical cure.

Varieties of Inguinal Hernia.—Inguinal herniæ are divided into *direct*, which is always acquired, and *indirect* or *oblique*, which may be congenital or acquired (see Anatomy). In a direct hernia the protrusion is mesal, while in an indirect hernia it is lateral to the deep epigastric vessels. If the protrusion passes through the external abdominal ring into the scrotum or labium majus it is termed a complete or scrotal hernia; if not, an incomplete hernia or bubonocele.

Direct Inguinal Hernia.—Direct inguinal herniæ constitute seven per cent. of all inguinal herniæ. They are more common in men than in women and are seldom seen in children. They are always acquired. They are seldom complete and may usually be recognized by their globular shape and by the fact that they appear to bulge directly through the abdominal wall as the border of the rectus muscle through the undefended space (*vide supra*).

Indirect Inguinal Hernia constitutes the greater part (ninety-three per cent.) of inguinal herniæ. The hernia may descend into the unobliterated processus vaginalis either in the male or in the female, being then called congenital hernia (Fig. 3147, *A*); or its sac may be formed by the protruded peri-

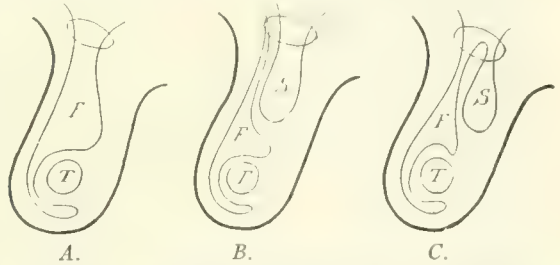


Fig. 3147.—Formation of Sac in Congenital and Infantile Hernia. *A*, Congenital hernia; *B* and *C*, infantile hernia; *F*, funicular process; *S*, sac; *T*, testicle.

toneum of the abdomen—acquired hernia. The proportion of congenital to acquired herniæ is difficult to state, as the diagnosis is made only by operation. A study by Bull and Coley[8] of 500 cases of inguinal hernia operated upon in children under fourteen years of age showed that less than fifty per cent. were congenital. In the opinion of the writer the majority of acquired indirect inguinal herniæ are due to persistence of the lumen of the upper portion of the processus vaginalis peritonei; for when a hernia is present on one side only this condition will be found almost invariably on the other side.

A form of hernia known as *infantile hernia*, although always acquired, is sometimes confounded with congenital hernia. The hernial sac in these cases is formed from the parietal peritoneum and is pushed down alongside of an open or partially obliterated funicular process; the different varieties of this form depend upon the extent and the site of the obliteration (Fig. 3147, *B* and *C*). Since the unobliterated funicular process is often spread out over the hernial sac, the latter appears as a sac within a sac; hence the term encysted hernia.

Perineal Hernia.—The protrusion instead of descending into the scrotum may descend into the perineum.

Interstitial Hernia is a form of inguinal hernia in which the protrusion insinuates itself between the layers of the abdominal wall. According to Langdon[9] the frequency of interstitial hernia is 1 in 1,100. It is relatively more common in females than in males, forming 0.13 per cent. of all inguinal herniæ in males and 0.61 per cent. in females.

Three varieties are recognized. In order of frequency they are: (1) Between the internal oblique and the aponeurosis of the external oblique; (2) between the aponeurosis of the external oblique and the skin; and (3) between the peritoneum and the transversalis fascia (properitoneal hernia). The first two varieties present an external swelling, while no visible or palpable tumor is found in the last variety. In the majority of the cases of the last variety there is also a

scrotal or labial hernia. Such an accompaniment is seldom observed in the first two varieties. In fact the sac of a properitoneal hernia is usually a diverticulum of the sac of a complete hernia: and herein lies its danger, since a false idea of security may follow reduction of the complete portion.

The causes contributing to the production of interstitial hernia are efforts at reduction, giving rise generally to the properitoneal form; and errors in development, namely, non-descent of the testicle or incomplete closure of the canal of Nuck. Macready states that in sixty-seven per cent. of the cases in males the testicle was wholly retained or only partially descended. According to Langdon,[11] in forty-two cases of interstitial herniæ in males in only two were the testicles in normal position in the scrotum.

The second and third varieties may acquire very large dimensions. Inasmuch as it is difficult to retain an interstitial hernia by a truss, operation is indicated.

Diagnosis of Inguinal Hernia.—The subjective symptoms are pain, which is present in ninety-six per cent. of all cases in the early stages, and later a sense of fulness and discomfort. The chief objective sign is a tumor, which as a rule disappears when the patient lies down but returns upon his standing, coughing, or crying. Impulse is present in reducible forms, and in complete hernia the contents may be felt to descend by the finger introduced into the canal.

Incomplete hernia or bubonocele must be differentiated from femoral hernia, hydrocele of the cord or canal of Nuck, inflammatory conditions and new growths of the inguinal glands and cord, psoas abscess, and undescended testicle. It is distinguished from femoral hernia by its relation to Poupart's ligament and the spine of the pubis; from hydrocele by the irreducibility, circumscription, and fluctuation of the latter; and from psoas abscess by the presence in the latter condition of a deep-seated swelling above Poupart's ligament, between which and the visible protrusion fluctuation can be obtained.

The conditions most commonly confounded with complete inguinal hernia are hydrocele, hematocele, varicocele, and tumors or inflammatory conditions of the testicle or epididymis. Very rarely femoral herniæ descend into the scrotum or labium. The statements of the patient as to the position and growth of the swelling at its incidence, taken with the characteristic signs of the several conditions, will serve, as a rule, to make the diagnosis evident.

Treatment of Inguinal Hernia. (For treatment by truss see "Mechanical Treatment of Hernia.")

Radical Cure of Inguinal Hernia.—The operative methods devised for the cure of inguinal hernia are so numerous, and so many have become obsolete, that the reader must be referred to special treatises for the details of those operations which have a historical interest only.

The success with which radical cure is performed at the present time is due primarily to the almost uniform aseptic healing obtained, and, secondly, to the improvements of technique and method. The aim of present methods is to secure the least possible scar formation, and the production of a muscular contractile barrier against future relapse.

Methods depending upon the use of foreign materials to form an obturator have been advanced in the last few years but have not become popular, largely on account of the inherent difficulties in getting such substances to remain within tissues of the body without giving rise to trouble.

The methods which have been most commonly in use and which have given the best results are the following: Bassini's (1888), Halsted's (1890), Kocher's (1892), Macewen's (1886), and restoration of the inguinal canal as practised by Bull, Ferguson, and others. A number of slight modifications of the above methods which might be called the classic methods have been advocated, more of which, however, are recombinations of methods, such as for instance methods of imbricating the aponeurosis of the external oblique muscle, which was first done by Lucas-Championniere, and of treating the sac by infolding or using it as a suture.

For very large herniæ, giant hernia (Riesenbruche) some ingenious flap operations have been advocated such as the employment of the sartorius (Jacoborici[10])

Bassini's Method.—This operation or some slight modification of it undoubtedly has been done more frequently than any other in recent years. The steps of the operation are as follows: The incision is made parallel with Poupart's ligament and two centimeters above it, from a point laterad to the internal ring to a point corresponding to the center of the external ring. The length of the incision is seven to nine centimeters in adults and shorter in children.

The incision is carried directly to the aponeurosis of the external oblique, and if properly planned should strike it in the line of divergence of the pillars of the external ring. The superficial structures should not be stripped from the aponeurosis since its vitality is thereby impaired. The aponeurosis is then slit in the direction of its fibers for a distance of five to six centimeters from the external ring, care being taken not to wound the underlying structures. The upper lip of the aponeurosis is then stripped from the surface of the internal oblique and the sheath of the rectus for a distance upward of about three centimeters. This separation is important, as it facilitates the bringing down of the fibers of the internal oblique in the final steps of the operation. The tissues covering the cord and sac are similarly stripped from the lower lip of the aponeurosis until the deep surface of Poupart's ligament is well exposed as far as its insertion to the pubic spine. This clearing of the deep surface of the external oblique is best done by blunt dissection, the instrument being swept toward the middle line in the direction of the aponeurotic fibers.

The sac and cord enclosed in their coverings now lie freely exposed, and the second step of the operation, the isolation of the sac, is commenced. A longitudinal incision is made through the cremasteric and transversalis fascia, exposing the sac at its uppermost part (Fig. 3148). The assistant now catches the sac with two toothed forceps, one at each extremity of the incision, and lifts it upward, while the operator seizing the margin of the fascia nearest to him, *i.e.* on the outer aspect of the sac, draws it away from the sac. The vessels of the cord now appear and must be freed from the sac by a few light touches of the knife. Just beneath the vessels on the outer side of the sac the vas deferens is recognized and is to be freed in a similar manner. The operator in grasping these structures should use smooth forceps and make very light pressure. As the dissection is carried around the sac the assistant shifts his hold, so that at all times the sac is kept tense. If any vessel is divided in this dissection it should be immediately caught and tied so that the field may not be obscured.

The cord now being isolated from the neck of the sac, the finger is inserted between it and the sac from without inward, and curved about the latter; in this way the remaining attachments of the fascia on the inner aspect of the sac are easily stripped off over the point of the finger and the neck is completely circumscribed. The direction of the encircling finger may now be reversed, and the stripping of the sac can be readily accomplished by pushing the cord away from it with gauze, this being aided by a few touches of the knife.

If this procedure is carried out with extreme gentleness subsequent swelling of the cord rarely occurs.

The fundus of the sac having been freed, it is lifted up, and the internal oblique having been retracted

to expose the internal ring, the freeing of the sac is carried upward beyond its neck to the point where it flares out into the parietal peritoneum. On the inner aspect of the neck considerable subperitoneal fat will be found, and in large indirect as well as in direct herniæ this may contain the bladder. In congenital hernia the sac is cut in two, the lower portion being of sufficient size to cover the testicle, over which it is sutured.

The third step of the operation comprises opening of the sac, reduction of its contents, and ligation of the neck. Adherent masses of omentum are treated in the usual manner by chain ligation. Ligation of the sac is done by drawing it down as far as possible, its mouth being kept open, and then transfixing its neck as high as possible with a needle carrying heavy catgut. The ligature is tied around each half of the neck separately and then around the entire neck, and the sac is cut off. If the neck is too large for ligation it must be sutured (Fig. 3149).

The fourth step is the most important, and herein lies the peculiarity of the Bassini operation, namely, the transplantation of the cord and the suture of the internal oblique* to Poupart's ligament. The cord is first freed from its bed and retracted to the outer part of the incision against the point of origin of the internal oblique from Poupart's ligament.

The first stitch is taken on the inner side of the cord, the needle passing through the whole thickness of the internal oblique 1.5 to 2 centimeters from its margin, and then picking up the deep shelving portion of Poupart's ligament. This suture should just touch the cord when it is held at right angles to the wound. Three or four similar sutures are then taken until the spine of the pubis is reached. The last suture takes in the conjoined tendon, and it is often better to include also in it the margin of the rectus, especially when the insertion of the internal oblique does not extend down to the pubic spine (Fig. 3150).

The writer, following the example of W. B. Coley, always puts a suture on the outer side of the cord, but he differs from Coley in that he inserts and ties it up before the other sutures are introduced, while Coley puts it in last. This suture subserves two purposes: it gives the muscular fibers a lower plane at their origin and it places the point of emergence of the cord at a greater distance from the internal abdominal ring, thus giving the latter additional protection. The sutures should be tied without tension to avoid strangulation of the muscle fibers.

The best suture material is one that will be absorbed in about thirty days. Kangaroo tendon fulfils this condition best, then chromicized catgut. Non-absorbable suture material should not be used. for the sutures are only supposed to hold until repair has taken place. It is well known that any suture will cut through tissue, even bone if there is a constant strain upon it. Furthermore non-absorbent sutures act as foreign bodies and promote cicatricial tissue formation if not infection and suppuration.

The next step is the suturing of the external oblique which is done so as to include the cord between it and the internal oblique. A continuous suture is sufficient, or the aponeurosis may be imbricated.

The cutaneous incision is then closed with or without drainage, according to the operator's technique.

In the female the steps of the Bassini operation are carried out as in the male, with the exception that in the description of the procedures the round ligament is to be understood whenever the cord is mentioned.

The writer, however, believes it to be a mistake to transplant the round ligament (*vide infra*).

Suture of the muscles without transplantation of the cord, i.e. restoration of the inguinal canal, was practised consistently on most herniæ in children by W. T. Bull in the early '90's (Bull and Coley[11]) and is the essential principle of the Ferguson operation. In the opinion of the writer it should be the choice of methods when the transversalis fascia forming the dorsal wall of the inguinal canal is well developed; that is in small and oblique herniæ, and when the internal oblique muscle is well developed and can be easily approximated to Poupart's ligaments (*vide infra,* Discussion of Choice of Methods).

Transplantation of the Rectus Muscle.—To meet the condition in which the transversalis fascia forming the dorsal wall of the canal is deficient and the neck of the

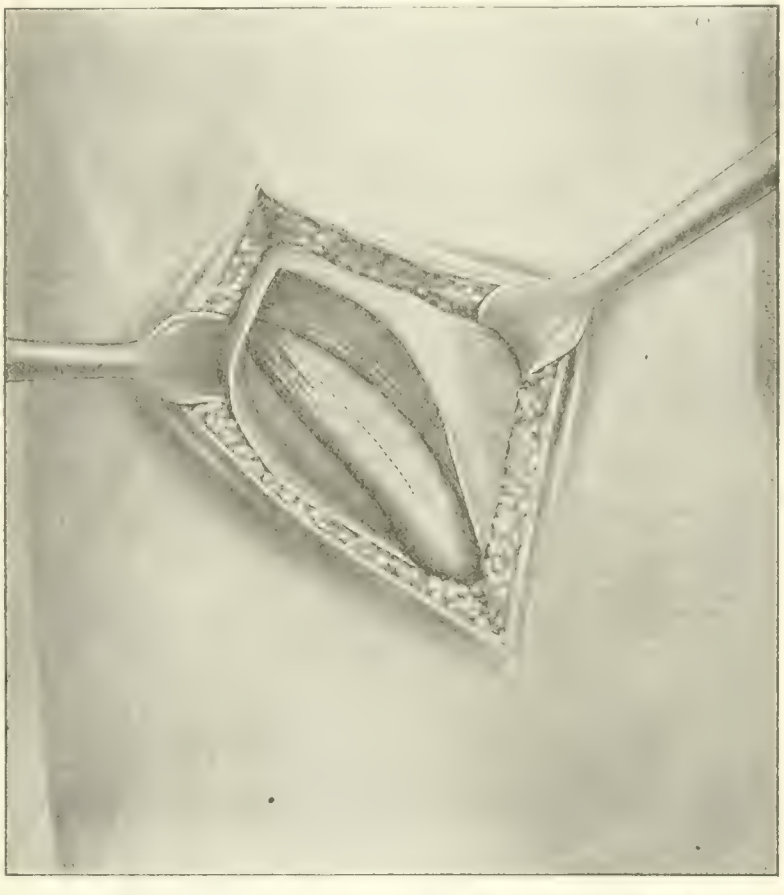


Fig. 3148.—Operation for the Radical Cure of Inguinal Hernia, Bassini's Method. External oblique divided and retracted. Sac in place. Line indicates incision preliminary to separation of cord from sac.

*The internal oblique muscle is alone mentioned, since it is practically the only structure sutured to the ligament. See the section on Anatomy.

hernia is very large, Bloodgood[12] devised a most excellent method of transplanting the rectus muscle by slitting its deep or dorsal sheath and drawing it down with the internal oblique to Poupart's ligament. This method is superior to Wölfler's[13] in that the latter operator slits the ventral sheath, thus destroying the insertion of the internal oblique and transversalis at that point. Bloodgood originally did his operation in conjunction with the Halsted operation (Fig. 3154). The writer has used his method of opening the sheath, but has stitched the rectus to Poupart's ligament first and brought the internal oblique down in front of it as in the Bassini operation. This procedure is of great value when there is a large undefended space as is usually the case in direct hernia. In these cases (*vide supra*, Anatomy) the lower border of the internal oblique muscle is a considerable distance cephalad to Poupart's ligament, and bringing down the rectus muscle lowers the insertion of the internal oblique thus permitting its lower border to be approximated to Poupart's ligament with much less tension.

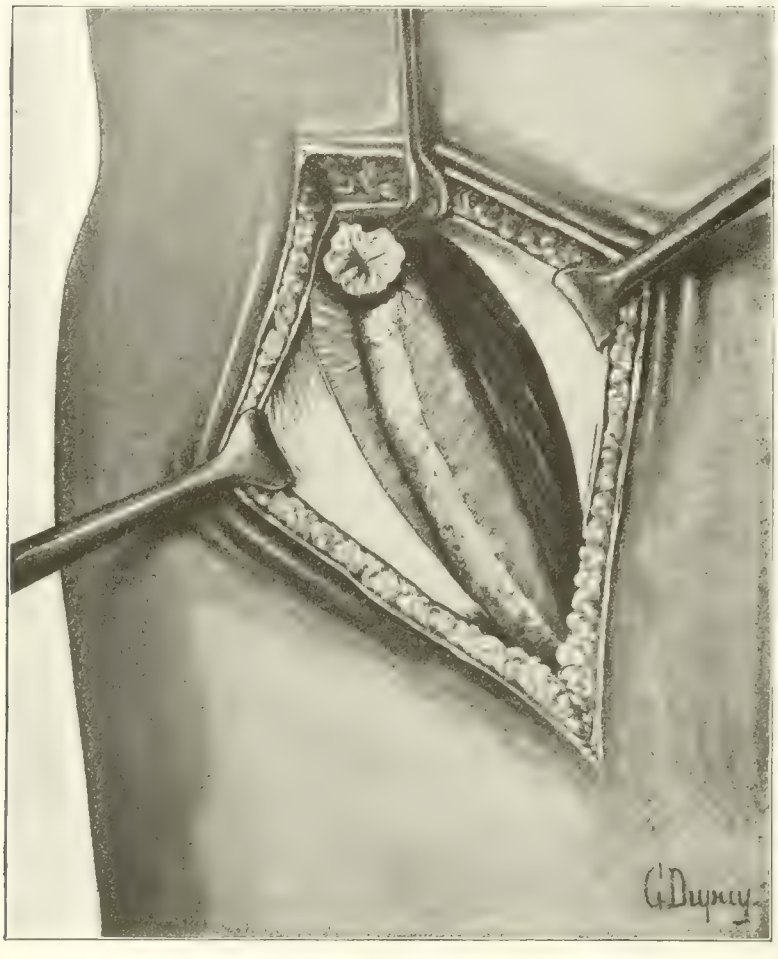


Fig. 3149.—Operation for the Radical Cure of Inguinal Hernia. Bassini's method. The margins of the aponeurosis of the external oblique muscle are retracted horizontally, the internal oblique upward, exposing the site of ligature of sac at the internal ring. The cord lies on the transversalis fascia.

Halsted's Method.[12]—The cutaneous incision, slightly more vertical than the Bassini, having been made, the knife is carried down from the outermost part of the external ring through the aponeurosis of the external oblique, the internal oblique and transversalis muscles, and the transversalis fascia to a point two centimeters above and slightly lateral to the internal ring. The sac is isolated as high as possible and resected, and the peritoneum is sutured.

The veins of the cord are excised with the exception of one or two. Mattress sutures are then introduced through the entire thickness of the abdominal wall above, with the exception of the skin and peritoneum, and through the transversalis fascia, Poupart's ligament, and the aponeurosis of the external oblique below, the sutures passing beneath the cord, so that when they are tightened the cord lies directly beneath the skin. The sutures are passed so that the distal cut ends of the internal oblique are sutured to Poupart's ligament; thus, as it were, rotating the muscle. Halsted usually employs silver wire (Figs. 3152 and 3153). It is at once seen that there are marked differences between this method and Bassini's. These are: 1. The division of the internal oblique muscle. 2. The transplantation of the cord to a position between cut ends of muscle fibers. 3. The bringing of the cord in a direct line through the entire muscular wall. 4. The excision of the veins. 5. The suture *en masse* of the muscle. These differences are considered by some to be objections.

In fact, in the relapses after Halsted's operation the descent usually occurs along the cord, and in order to obviate this he has lately transplanted the vas deferens alone. The failures of the operation may be attributable to the first three of the points above enumerated. The excision of the vein has, moreover, led to atrophy of the testicle in some cases.

Bloodgood's Method[12] is the same as Halsted's, with the addition, already mentioned, of including the rectus drawn out of its sheath in the lower mattress sutures (Fig. 3154).

The distinguishing features of Kocher's and Macewen's methods consist chiefly in their treatment of the sac.

Kocher's Method.—The aponeurosis of the external oblique is exposed but not divided. The sac is separated from the cord and the separation is carried up to the internal ring where the sac is ligated. A forceps is now thrust through the external oblique aponeurosis above Poupart's ligament and the sac is caught and drawn out of this opening. It is then laid on the surface of the aponeurosis, which is plaited over it with a sort of Lembert suture. These sutures also narrow the canal (Figs. 3155 and 3156).

Macewen's Method.—In this method the sac is folded with a sort of accordion plait by means of a suture, passed from its extremity back and forth through both its walls; the suture is then continued through the transversalis fascia and the muscles above the internal ring in a direction from within outward. The sac thus forms a pad at the ring. The internal ring is then narrowed by suturing the transversalis

fascia above it to Poupart's ligament with a mattress suture. Several stitches may be inserted.

The objection to these last two methods is that the sac, when stripped, and especially when ligated, is practically effete material, and it is unsurgical to retain it in the body.

Fowler's Method.—The posterior wall of the canal, consisting of the transversalis fascia and peritoneum, is divided from the internal ring inward to the border of the rectus, and the cord is displaced to this point. The internal ring and the transverse incision are then closed. The incision divides the deep epigastric vessels. The canal may be closed by suture of the internal oblique to Poupart's ligament. This procedure is of particular value in cases associated with undescended testicle, in order to obtain additional length of cord.

Lucas-Championnière's Method.—The peculiarity of this method lies in the manner of closing the canal. The muscles and aponeurosis of the upper lip of the wound are brought down over the aponeurosis of the lower lip and retained by mattress sutures, thus producing an overlap.

Remarks.—The chief accidents happening from operations for radical cure are injury of the vas deferens, hemorrhage from omental stumps, to be avoided by including only small masses, pneumonia following the anesthesia, and sepsis. The occurrence of sepsis largely increases the percentage of relapses.

The mortality is slight. Bull and Coley[9] have found it to be 0.9 per cent. in 10,000 operations performed between 1886 and 1897. In 2,000 later operations the mortality was less than 0.2 per cent. No operations for strangulated hernia are included in these lists.

As a rule children under four years of age and adults over fifty should not be operated upon, inasmuch as many children are cured by the wearing of a truss, and in the aged the hernia can be controlled by truss with less inconvenience than in the younger and more active, while the dangers of operation are greater. Patients with bronchitis should defer operation; but in cases of chronic respiratory diseases, and when the necessity presses, it may be done under local anesthesia after Cushing's method. As before stated, large irreducible herniæ are not suitable for operation. The best results are obtained in children and young adults.

A routine method should not be employed. The operation should be modified to meet the conditions present in any given case.

As already stated, in children and in cases where the dorsal wall of the inguinal canal is strong the internal oblique muscle should be attached to Poupart's ligament without transplantation of the cord. In direct hernias or in large oblique hernias that are practically direct, the cord should be transplanted with or without drawing the rectus muscle down. Imbrication of the aponeurosis of the external oblique is of doubtful value, because in order to imbricate it, it must be denuded on both surfaces and its vitality is thereby impaired. In direct hernia the transversalis fascia should be sutured and if possible overlapped to overcome its laxity. In this variety it is impossible sometimes to ligate the sac which must therefore be sutured also.

Statistics which are based on a routine procedure without selection still show the best results from the Bassini operation which goes to prove that it is a thoroughly good procedure, and also that operation without transplantation of the cord should be restricted to selected cases. In 1900 when this article was first written the statement was made that the percentage of relapses after the Bassini operation was probably not greater than five in good hands. Coley[14] reports 500 cases, chiefly in children, traced with 6 relapses. Galeazzi[15] has collected 1,334 cases operated upon by surgeons out of Italy, with only 2.16 per cent. of relapses. The Halsted method has given 6.5 per cent. relapses.

The latest statistics up to 1913 give about the same results, but if the cases were divided into two classes the first comprising those in children and those with small oblique herniæ and the second, those in older patients with larger herniæ and direct herniæ,

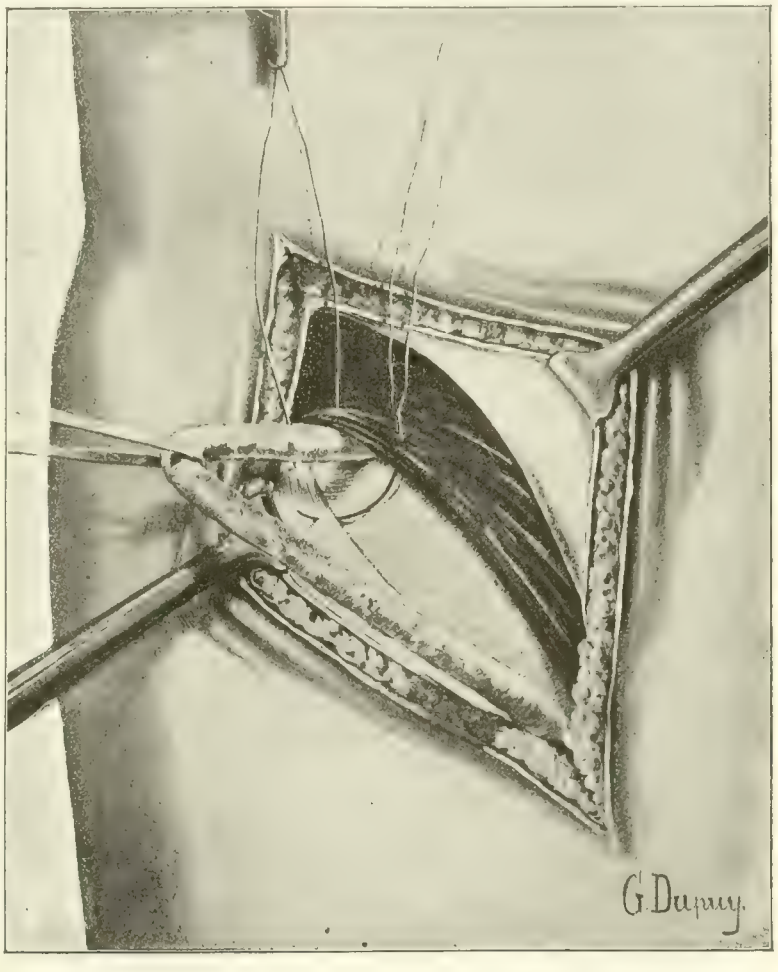
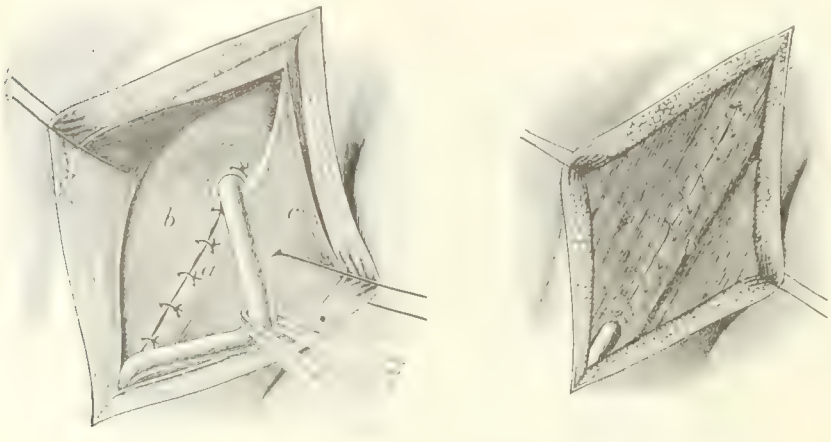


Fig. 3150.—Operation for the Radical Cure of Inguinal Hernia, Bassini's Method. Sac removed, cord drawn aside, and lower fibers of the internal oblique and transversalis muscles stitched to Poupart's ligament from without inward. The transversalis fascia appears at the deepest part of the field of operation. The stitches should grasp more of the interior oblique muscle than is shown in the drawing.

the discrepancy in the results would be found to be great and that then would probably be at least twenty-five per cent. of relapses in the later class of cases.

necessary after operation for any variety of hernia, although sometimes for especial reasons a longer period may be desirable.

Trusses After Operation.—In children and young adults in whom there is good muscular development and the hernia has not been very large, a truss is unnecessary. Each case has to be judged by itself.



A *B*

FIG. 3151.—Operation for the Radical Cure of Inguinal Hernia. Bassini's Method. A, Arched muscular fibers and conjoined tendon (*b*) sewed to Poupart's ligament (*c*). *a*, aponeurosis of external oblique muscle. B, Aponeurosis of external oblique (*a*) sewed with continuous suture (*b*) to Poupart's ligament (*c*). (From "Bryant's Surgery." D. Appleton & Co.)

FEMORAL HERNIA.—A femoral hernia is one that descends in or alongside the femoral sheath. The most common form is that in which the gut or omentum descends through the crural canal, which lies at the mesal side of the femoral vein. In rare cases the hernia may descend in front of the vessels or even on their lateral aspect.

The name Hesselbach's hernia has been given to the one descend-

Hernia Associated with Undescended Testicle.—The treatment of this condition is still the subject of considerable controversy. The weight of opinion seems to be that children under ten or twelve years of age should have mechanical treatment if a truss can be constructed so as to crowd the testicle down. In case of operation the testicle should be preserved if possible.

Anchoring of the testicle to the bottom of the scrotum is useless, it should rather be crowded down by passing deep sutures through the deep fascia of the canal.

The cord should not be transplanted, as distance can be gained otherwise.

Fowler's method of dividing the transversalis fascia so as to allow the cord to pass straight through the abdominal wall at the external ring affords more distance.

Bevan's method of dividing the vessels of the cord increases its length so that in nearly all cases the testicle can be brought down into the scrotum. Care should be taken not to divide too many vessels and cause necrosis of the gland.

Operations in children under fourteen years give the best results, as the testicle is more likely to become scrotal if retained outside the external ring before the changes incident to puberty have taken place. In the opinion of the writer the best age at which to operate is in the eighth or ninth year.

Postoperative Treatment.—The patient remains in bed in the reclining position for seven to fourteen days depending upon the ideas of the operator, but since the repair tissue is not firm until about the fourteenth day it would seem folly to risk the result of the operation for the slight inconvenience of a few additional days in bed. This may be stated as the time

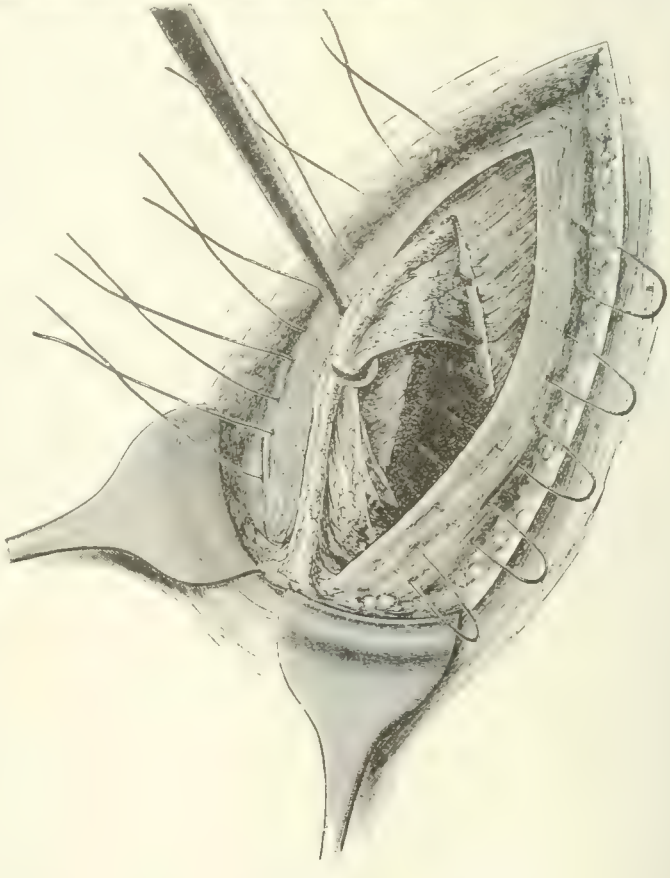


FIG. 3152.—Operation for the Radical Cure of Inguinal Hernia. Halsted's Method. Veins ligatured and resected. Mesocord torn only at its center. Silver sutures inserted, one above and four below the cord. (From "Bryant's Surgery.")

ing in the lacuna muscularis on the outer side of the femoral artery; Cloquet's hernia to the one that descends through the compartment for the femoral vein on its mesal aspect, spreading out on the pectineus

Fig. 3153.—Operation for the radical Cure of Inguinal Hernia Halsted's Method. Aponeurosis of external oblique closed by silver-wire mattress sutures, ends bent down and buried. (From "Bryant's Surgery." D. Appleton & Co.)

muscle, and Laugier's hernia to one descending through Gimbernat's ligament. Retrovascular herniæ have been mentioned but it is doubtful if they can occur (Moschcowitz[16]).

Anatomy.—The femoral sheath is formed by the funnel-shaped process of the transversalis fascia, which is prolonged from the abdominal cavity downward dorsad to Poupart's ligament into the thigh to form the sheath of the femoral vessels. The sheath is too large for the vessels at its commencement but contracts at the saphenous opening to enclose them snugly. Thus a space not occupied by the vessels is left on the mesal side of the vein, and is known as the crural canal. Its ventral boundary is Poupart's ligament; its mesal Gimbernat's ligament; its dorsal the iliopectineal line, Cooper's ligament, and the pectineus muscle; and its lateral the femoral vein from which it is separated by a septum of fascia. The space is filled with loose areolar tissue, the septum crurale, and a small lymph node (Fig. 3157).

The deep epigastric artery passes up on the lateral aspect of the canal. In about thirty per cent. of cases the obturator artery is given off from the deep epigastric and then is in relation with the crural canal; although it generally passes downward to the obturator canal on the lateral aspect of the crural canal, yet in three per cent. of all cases it passes down on its mesal aspect and is then subject to injury in herniotomy.

A hernia descending through the crural ring acquires as coverings the peritoneum, the subperitoneal fat which is usually very thick, the septum crurale, the transversalis fascia derived from the femoral sheath, the cribriform fascia, and the superficial fascia and skin.

The protrusion appears in the thigh below the fold formed by Poupart's ligament and below and laterad to the pubic spine. It is usually small and globular or hemispherical in shape. It may extend down the thigh as far as its middle or even farther. Occasionally it turns upward, and passing above Poupart's ligament may be mistaken for an inguinal hernia. Very rarely it may become scrotal or labial. The contents of the sac are more commonly entirely omental than in inguinal hernia. The omentum usually becomes adherent early, especially at the neck of the sac. The intestine is more apt to become strangulated than in inguinal hernia, and gangrene supervenes more quickly. Ferguson[17] has described a femoral hernia containing the testicle.

Occurrence of Femoral Hernia.—Femoral hernia occurs more commonly in women than in men, the

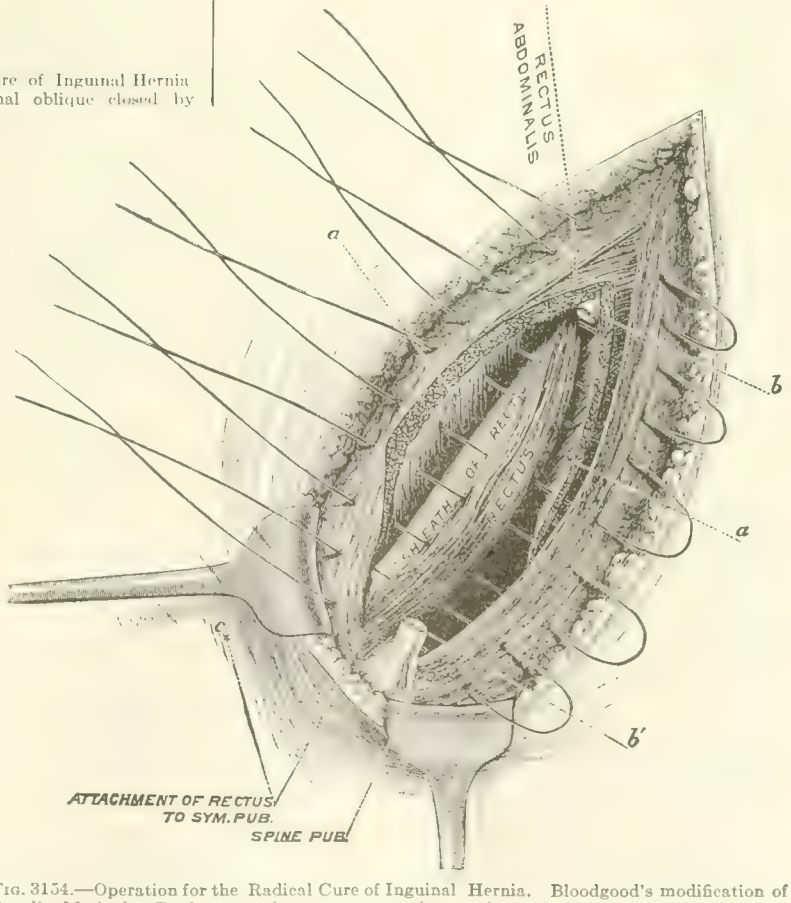


Fig. 3154.—Operation for the Radical Cure of Inguinal Hernia. Bloodgood's modification of Halsted's Method. Cord removed so as not to obscure demonstration. *a*, *a*, Divided borders of internal oblique muscle; *b*, *b'*, ends of resected cord. (From "Bryant's Surgery," D. Appleton & Co.)

ratio being about 3 to 1 in persons under fifty years of age. After this age the proportion of women ruptured decreases so rapidly that the relative frequency in the two sexes is nearly the same. As compared with inguinal hernia the frequency is 1 to 17 according to the statistics of the Hospital for Ruptured and Crippled[11] according to Macready[1] the ratio is 8 to 92. According to the same author, of 100 men ruptured, 97.5 per cent. have inguinal and 2.5 per cent. femoral hernia. Of 100 women ruptured 60.3 have inguinal and 39.7 per cent. femoral hernia.

As to the period of incidence, it is uncommon in early life, but occurs with greatest frequency in persons between sixteen and fifty years of age.

Causes predisposing to it are weakening of fascia resulting from stretching of the abdominal wall in pregnancy, and the greater size of the crural canal in women. Femoral hernia sometimes follows operation for inguinal hernia because of the pulling upward of Poupart's ligament by the muscles sutured to it, thus enlarging the femoral canal.

Diagnosis.—Psoas abscess, inguinal hernia, and saphenous varix may be confounded with reducible femoral hernia, inflammation and new growths of the lymph nodes with the irreducible form. In fat females the diagnosis between femoral and small inguinal herniæ it not always easy.

Treatment.—Unless contraindicated by general considerations, all femoral herniæ should be operated upon for the following reasons: They are more dangerous than inguinal herniæ, they are practically incurable by mechanical means, the operation is simple, and by it permanent cure is nearly always obtained.

Bassini's Method. The sac is exposed by an incision parallel with and slightly below Poupart's ligament. Having been cleared of fat and separated from the canal, the sac is drawn down as far as possible, transfixed, and ligated, after reduction of its contents, and the stump is allowed to recede into the abdominal cavity. Poupart's ligament, the pubic portion of the fascia lata, and the canal having been well cleared of fat, interrupted sutures are now introduced so as to unite Poupart's ligament with the pubic portion of the fascia lata covering the pectineus muscle, care being taken to avoid the femoral vein.

The upper sutures are inserted parallel with Poupart's ligament and pass into the pectineus muscle. The lower sutures unite the falciform process to the pubic portion of the fascia lata. The canal is thus closed (Fig. 3158).

Purse-string Method. The procedure in this method is the same as in the Bassini operation, with the exception that the canal is closed with a single purse-string suture passed in the following manner: A curved needle is introduced through Poupart's ligament and picks up the superficial fibers of the pectineus and its fascia, the falciform process, and finally emerges through Poupart's ligament a short distance from its point of entrance (Fig. 3159). When the canal is very large Bassini's method is preferable.

The writer[19] has successfully employed a method by which not only the opening below but the entire canal is obliterated. The incision is made parallel to Poupart's ligament and the external pillar of the inguinal ring is thoroughly exposed. After the usual treatment of the sac, a mattress suture is inserted through the external pillar of the inguinal ring and parallel to it so as to unite the pillar and its deep tissues to Cooper's ligament. This stitch closes the upper end of the canal and the lower end is then closed by uniting the falciform process to the fascia of the pectineus.

Gordon's Method. This method has been advocated by Bacon.[18] The incision commences two centimeters above Poupart's ligament and five centimeters from the pubic spine; it then passes parallel with the ligament to a point opposite the canal, where it turns down over the sac, thus exposing the aponeurosis of the external oblique, and the sac. The sac is isolated, its contents are reduced, and then the sac is resected and sutured or ligated flush with the peritoneum. The aponeurosis of the external oblique is split along its fibers, thus opening the inguinal canal, the contents of which are then separated from its lower surface, exposing the deep part of Poupart's ligament.

The transversalis fascia forming the femoral sheath is then separated from the ligament, thus opening the femoral canal. All the subperitoneal fat and connective tissue are removed from this region, and the internal oblique is united with mattress sutures to the ligamentum Cooperi and the pectineus muscle in such a manner as to cause its lower margin to be everted. The canal is thus closed by muscular tissue. The wound in the external oblique is then sutured and this is followed by closure of the superficial wound.

Barclescu[20] has described a method similar to Gordon's.

Pilcher[21] draws the stump of the sac up behind the abdominal wall by passing the ends of the ligature on a needle through the wall above the inguinal canal and tying them on the outside. Cavazzani[22] passes a mattress suture through the pectineus and the obturator foramen up behind the horizontal ramus of the pubes so as to catch Poupart's ligament and pull it down behind the ramus.

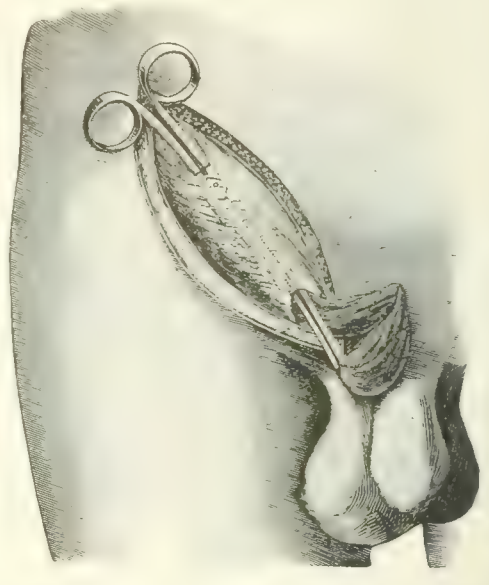


Fig. 3155.—Operation for the Radical Cure of Inguinal Hernia, Kocher's Method. Sac separated and end seized by forceps passed through the transverse incision (*a*) down the inguinal canal. (From "Bryant's Surgery." D. Appleton & Co.)

Results of Operation for Femoral Hernia.—The results of operation have been good and it seems strange that so many methods have been evolved. Bassini reports fifty-four cases, forty-one traced, with no deaths and no relapses. Coley has operated in the some number of cases (by Bassini's and the purse-string methods), most of which have been traced, with no deaths and but one relapse in a Bassini operation in which suppuration occurred.

Degarmo[23] reports 110 operations by a single method, *i.e.* suture of the free edge of Poupart's ligament to the pubic bone, with two relapses.

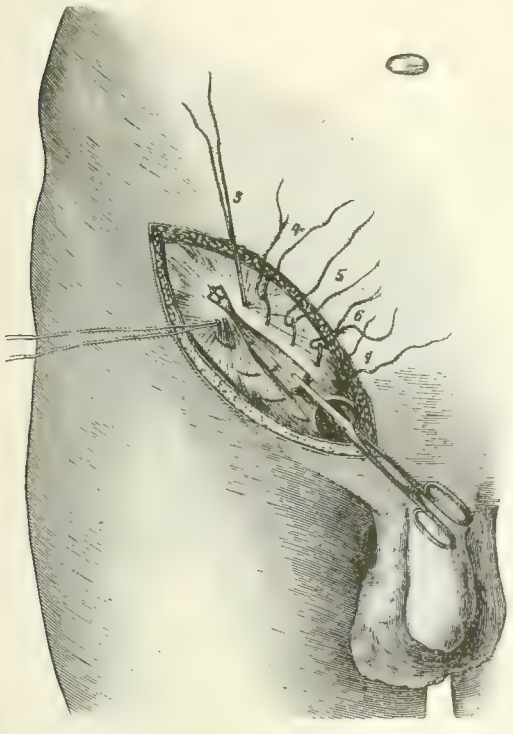


Fig. 3156.—Operation for the Radical Cure of Inguinal Hernia. Kocher's Method. Sac drawn downward on aponeurosis and sewed in place. (From "Bryant's Surgery." D. Appleton & Co.)

Umbilical Hernia.—Umbilical herniæ are divided into three classes: 1 Congenital umbilical hernia. 2. Infantile umbilical hernia. 3. Adult umbilical hernia.

Congenital Umbilical Hernia or Hernia of the Cord.—This condition is very rare, occurring according to Linfors[21] once in 5,184 cases. In embryos of ten millimeters, and that have not reached beyond the tenth week of development, a portion of the intestine is found in the cavity of the umbilical cord which is continuous with the body cavity. After that period the intestine usually recedes into the body cavity proper and the umbilicus is formed by the union of the visceral plates. However, if development of the abdominal wall be arrested, a varying amount of the viscera may be found in the cord at birth. The term congenital umbilical hernia is erroneous, since no umbilicus has been formed.

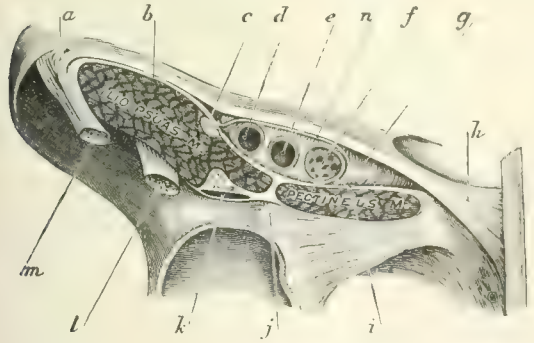


Fig. 3157.—Transverse Section below Poupart's Ligament. *a*, Anterior superior spine of the ilium; *b*, iliac fascia; *c*, anterior crural nerve; *d*, femoral artery; *e*, femoral vein; *f*, septum crurale; *g*, Gimbernat's ligament; *h*, spine of pubis; *i*, pectineal fascia; *j*, ilio-pectineal eminence; *k*, iliac bursa; *l*, rectus femoris muscle; *m*, sartorius muscle; *n*, transversalis fascia. (From "Bryant's Surgery." D. Appleton & Co.)

The wall of the hernia consists of membrane derived from the same layers that form the amnion. The contents may be a varying amount of intestine alone, the liver alone, or the liver, stomach, spleen, and intestine, *i.e.* complete eventration. In the latter variety the wall nearly always ruptures at birth and death rapidly ensues. In cases in which the concents can be reduced into the abdominal cavity and the cavity closed, operation gives better results than palliative measures. Of 90 cases collected by H. E. Safford[24] 64 were treated by laparotomy and suture with 65.6 per cent. recoveries; 1 case by simple ligature, with recovery; 3 cases by percutaneous ligature, with 1 recovery; 5 cases by Olshausen's method, with 100 per cent. of recoveries. Of 15 cases treated expectantly, 47 per cent. recovered.

Olshausen's method consists in separation of the skin around the sac, removal of Wharton's jelly, reduction of the hernia *en masse* without opening the sac, and suture of the skin.

Infantile Umbilical Hernia.—This form occurs in infancy and childhood and is due to weakness in the umbilical cicatrix. Berger[25] places the limit between it and adult umbilical hernia at fifteen years. It is about equally common in males and females, the ratio being 1 to 1.6 according to the statistics of the Hospital for the Ruptured and Crippled. According to Berger[25] it forms 22.42 per cent. of all herniæ occurring in male children and 65.34 per cent. of all herniæ in female children under fifteen years of age. This variety is always reducible and is quite amenable to treatment by a simple pad or truss and does not require operation.

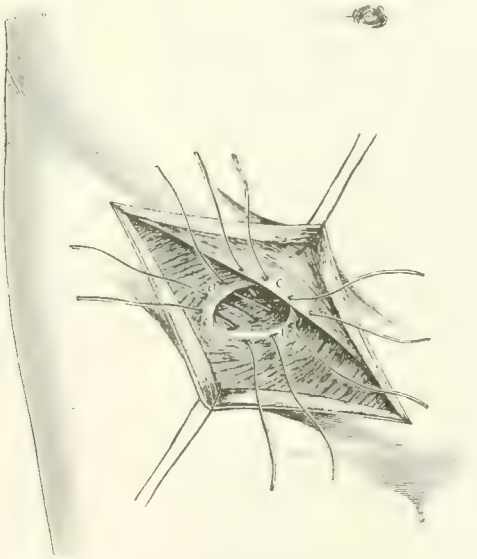


Fig. 3158.—Operation for the Radical Cure of Femoral Hernia. Bassini's Method. *a*, Falciform process; *b*, pubic portion of fascia lata; *c*, Poupart's ligament. (From "Bryant's Surgery." D. Appleton & Co.)

Adult Umbilical Hernia.—This variety is much more common in females than in males, constituting,

according to Berger, 22.16 per cent. of all herniæ in females and 2.5 per cent. of all herniæ in males over fifteen years of age.

Its greatest frequency is during the child-bearing period, and it is the most common of all herniæ in women at the age of forty years.

Two sub-varieties may be recognized, namely, those occurring without diastasis and those accompanied by diastasis of the recti. The first form em-

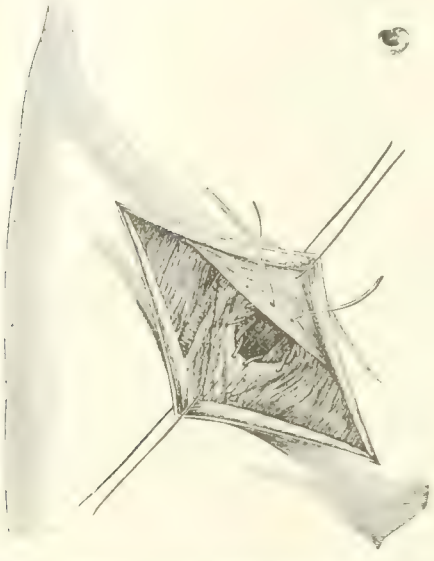


Fig. 3149.—Operation for the Radical Cure of Femoral Hernia. Purse-string suture, Cushing's Method. (From "Bryant's Surgery." D. Appleton & Co.)

braces the greater number of cases occurring in males; the hernia in this case is usually small. The second variety is more common in women, and the tumor may reach an enormous size.

The first form, that occurring without diastasis of the recti, resembles infantile hernia in both symptoms and treatment and rarely requires operation.

Hernia with diastasis is more serious and the symptoms are often most distressing. The hernia is apparently due to the progressive stretching of the abdominal wall from internal pressure or from strains. The umbilicus being the weakest point gives way and the most marked protrusion occurs at this point, although the protrusion may be diffuse and take in a varying amount of the linea alba.

The *coverings* of the sac consist of skin and peritoneum, little or none of the intervening fibrous tissue remaining between them.

The *contents* of the sac consist at first usually only of omentum which soon becomes adherent and irreducible. The transverse colon is found in the sac more commonly than any other part of the intestine.

Symptoms are due to the size of the hernia and to complications, such as adhesions, obstruction, etc. The size of the hernia is an inconvenience and it may ulcerate on account of the poor nutrition of its coverings. It may cause gastric or intestinal symptoms from the inclusion of large amounts of viscera and from the dragging of adhesions. Being commonly associated with loose and pendulous abdominal walls, it is often accompanied by the symptoms of enteroptosis. Pain from adhesions and attacks of local peritonitis are common. Strangulation occurs about as frequently in umbilical as in other herniæ, but the mortality from strangulated umbilical hernia is greater. In gangrenous hernia, according to Gibson,[6] the mortality of umbilical hernia is 67 per cent. of inguinal hernia 26 per cent., and of femoral hernia 37 per cent.

Treatment.—Small reducible umbilical herniæ are best treated by truss. Many of the larger ones can be helped by a well-fitting abdominal support when a pad cannot be worn on account of the irreducibility of the contents.

Many cases of hernia in adults are not suitable for operation inasmuch as this is difficult and often prolonged by adhesions, etc., and because the patients, who are, as a rule, obese women in middle life, bear operations poorly.

In younger women of good fiber, although fat, especially if the protrusion is not too large, operation should be performed, because the hernia tends to increase in size and with the increase in size come the distressing symptoms and complications, and the chance for complete radical cure diminishes. Aside from the risk of operation (the mortality is about 5 per cent. in irreducible cases), the success in regard to permanent cures by the older methods has not been great. According to Berger,[23] in 30 per cent. of large herniæ and 15 to 20 per cent. of herniæ of moderate size relapse occurs, while in small herniæ the relapses are practically *nil*. In cases in which suppuration occurred, the percentage of relapses was 60. Ruge[26] reports similar results in 79 cases operated upon.

As would be expected from such poor results, a number of methods of radical cure have been devised. These methods may be classified according to the method of repairing the defect in the abdominal wall. In considering operative methods it must be

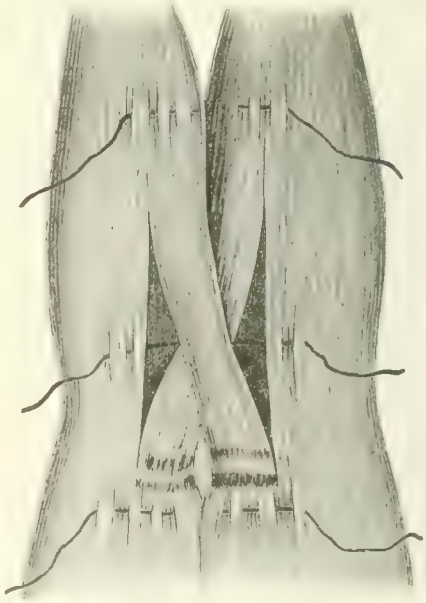


Fig. 3160.—Operation for the Radical Cure of Umbilical Hernia. Dauriac's Method. Muscular segments transferred and united, and sutures laid for closure. (From "Bryant's Surgery." D. Appleton & Co.)

remembered that in cases of diastasis of the recti the entire abdominal wall becomes thinned and stretched as well as the linea alba, so that the recti muscles may become more than twice their normal width and less than half their normal thickness.

Lineal Approximation of Fascia or Fascia and Muscle (Condamin,[27] Socin, Sanger,[28] Gersuny[29]). After excision of the sac and reduction of its contents, the abdominal wall is sutured layer by layer. In small

herniæ the sheaths of the recti may be split and the muscles themselves approximated as well as their sheaths (Socin, Sanger). This method is unsuitable n hernia with diastasis of the recti.

Interlacing of the Recti (Bacon,[30] Dauriac[31]). In order to fill up the hiatus present after excision of the sac, the inner portions of the recti are split off, and having been cut free at one end are transplanted to the opposite side, thus producing an interchange of portions of the recti following the figure of a cross (Fig. 3160). The chief objection of this method is the impairment of innervation and nutrition in the transplanted muscle.

Involution of Abdominal Wall (Lucas-Championnière[32]). The margins of the wound are turned in, thus bringing in apposition the ventral surfaces of the aponeurosis, and retained by means of a series of sutures resembling the Lembert suture. This method is applicable only to cases in which the abdominal walls are very lax.

Flap Operation (Noble,[33] Diakonoff and Starkoff,[34] Heinrich,[35] Hagen,[36] Ferguson[37]). A flap is cut from the ventral sheath of one rectus muscle and is carried across and united to the sheath of the opposite muscle; or a flap is taken from each sheath, the two being joined so as to close the hernial opening. The margins of the flaps may be united or the flaps may be lapped. The flaps are cut so that their attached borders are at the mesal borders of the recti, and when turned in and united their ventral surfaces become dorsal. The chief objection is the lack of nutrition of these flaps.

Lapping of the Abdominal Wall (Mayo,[38] Piccoli,[39] Sapiejko,[40] Blake[41]). This method is particularly adapted to cases with diastasis of the recti and pendulous abdominal walls. It is also suitable to protrusions in the linea alba elsewhere than at the umbilicus. It consists in the excision of a large elliptical area of skin and fat in either a vertical or a transverse direction, down to and exposing, on one side at least, very completely the sheaths of the recti. In typical operations done by the writer the incision has included an area from 25 to 40 centimeters in length and 15 to 20 centimeters in width. The sac is partially or wholly excised and the linea alba is divided for the whole length of the skin incision. The peritoneum is separated if possible from the dorsal surface of one rectus. It is not necessarily opened except at the hernial sac. One musculo-aponeurotic wall is then lapped over the other, as seen in Fig. 3161.

In the writer's cases the amount of lapping has varied from 4 to 10 centimeters according to the laxity of the abdominal wall. In one case the greater part of the sac with adherent intestine and omentum was lapped under the opposite rectus. The margin of the underlapping side is sutured to the deep surface of the overlapping side by mattress sutures of chromicized gut which are tied on the superficial surface of the latter. The margin of the overlapping side is tacked with interrupted sutures of the same material to the superficial surface of the underlapping side. The skin wound is then closed without drainage. The results by this method in the hands of the writer and as reported by others have been excellent. Mayo uses a transverse incision and laps the upper margin down over the lower margin. This method has the advantage of not diminishing materially the capacity of the abdomen and can be used when the abdominal walls are not relaxed, while the method of lapping from side to side markedly diminishes the capacity of the abdomen and may seriously incommode respiration, leading to death from pneumonia due to non-aeration. The side to side method should therefore be reserved for cases with great diastasis and lax abdominal walls.

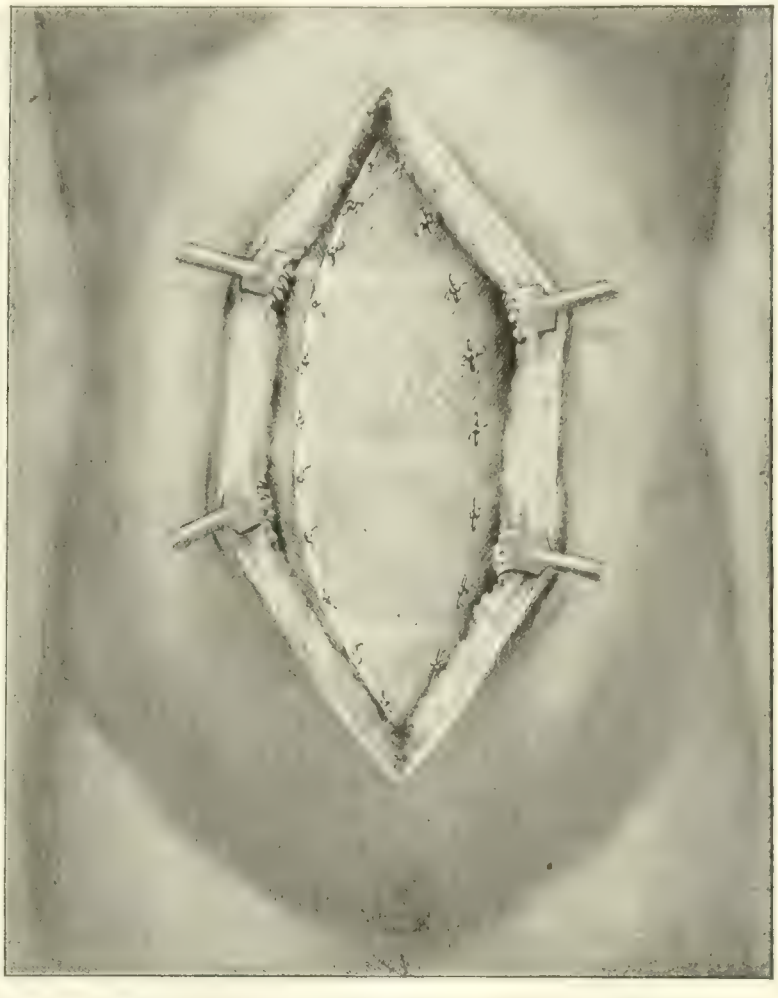


Fig. 3161.—Operation for the Radical Cure of Umbilical Hernia. Method by overlapping of abdominal wall. The right rectus muscle is lapped in front of the left.

Ventral Hernia.—Ventral hernia is the general term applied to all herniæ of the abdominal wall excepting umbilical and groin herniæ. The herniæ may occur at any part of the abdominal wall. The term therefore includes: (1) Hernia in the linea alba elsewhere than at the umbilicus; (2) diastasis of the recti; (3) hernia in the lineæ semilunares; (4) hernia in the lineæ transversæ; (5) lumbar hernia; (6) traumatic hernia.

Hernia in the Linea Alba.—These herniæ, leaving out umbilical herniæ and those due to diastasis of

the recti, occur four times as frequently in males as in females (Macready). They are rare in early life, and most frequent at middle age.

Two varieties occur: 1. Herniæ above the umbilicus—epigastric hernia. 2. Herniæ below the umbilicus.

Epigastric herniæ are usually small and may be multiple and are situated at any point between the xiphoid and umbilicus. They are protrusions through the gaps which are not uncommon between the decussating fibers of the linea alba in this region. They may consist only of properitoneal fat or there may be a well-defined sac with omental or intestinal contents. Three cases of strangulation are reported (Hotchkiss[42]). Symptoms are out of all proportion to their size and contents, and consist of pain with gastric and intestinal disturbances. They may be retained by truss, but operation is better. The aperture may be closed transversely or vertically.

Herniæ of the linea alba below the umbilicus are often confused with diastasis of the recti. They occur within five centimeters of the umbilicus, as a rule. They may acquire considerable size. They are best treated by a truss such as is used for umbilical hernia or by operation.

Diastasis of the Recti.—This occurs in childhood and at middle life. In children it occurs as a bulging of the linea alba above the umbilicus, and disappears with the growth of the child.

In adults it occurs practically only in women who have borne children, at or before middle life. It is usually most pronounced below the umbilicus although the whole linea alba suffers. It may be so pronounced that there remains only a thin pendulous bag enclosing a large part of the intestines and sometimes the gravid uterus.

The treatment is by means of an abdominal support. If operation is feasible, that of lapping the abdominal wall (see Umbilical Hernia) will be found peculiarly adapted to these cases.

Hernia in the Lineæ Semilunares.—This is a rare form occurring usually at the level of the semilunar fold of Douglas. About twenty-three cases have been observed. The protruding mass occasionally penetrates only a part of the abdominal wall, resulting in a "masked hernia."

According to some writers direct inguinal herniæ are herniæ of the linea semilunaris, but the writer cannot concur in this, since in these cases the contents of the hernia push forward the transversalis fascia and escape below the insertion of the transversalis and internal oblique muscles.

Hernia in the Lineæ Transversæ.—This is very rare, only seven cases having been observed at the London Truss Society in sixteen years (Macready).

Lumbar Hernia.—Twenty-six cases of this variety have been collected by Macready, one has been observed at the Hospital for the Ruptured and Crippled, and a congenital one has been reported by Dowd.[43] They occur at or near the tips of the eleventh and twelfth ribs, or at Petit's triangle, between the origin of the latissimus dorsi and that of the external oblique from the crest of the ilium. They occur more frequently in adults than in children and are usually reducible. In six of Macready's cases there was strangulation.

Traumatic Ventral Hernia.—This term includes hernia occurring through scars of accidental or laparotomy wounds. Not infrequently bulgings of the abdominal wall occur at a distance from a wound, which are due to destruction of the innervation of the muscle. Those following laparotomy are more frequent after lateral wounds than after wounds in the median line. They follow most frequently wounds that have healed by granulation, as for instance suppurating appendicitis wounds. Long wounds are more apt to be weak than short ones. The so-called "through-and-through suture" is responsible for many. More careful methods of making and closing abdominal wounds have lessened to a marked degree the frequency of this distressing condition which is a blot upon the page of abdominal surgery.

The treatment is largely prophylactic and consists in fitting an abdominal support to all weak laparotomy wounds. Most herniæ of this variety are best treated by operation. The muscular and aponeurotic layers should be carefully isolated and separately sutured. The sac may be resected and the peritoneum sutured, or in some cases the peritoneum may not have to be opened. Troublesome adhesions are usually present in those cases in which there has been intra-abdominal drainage for suppurative conditions.

In cases in which the gap was very large, obturators of silver wire netting have been introduced (Phelps[44]).

Obturator Hernia.—This rare form of hernia passes through the obturator canal, which opens at the mesal and anterior part of the obturator membrane for the passage of the obturator vessels and nerve. The vessels and nerve as a rule lie on the dorsolateral aspect of the sac.

The protrusion has for its coverings the peritoneum of the upper part of the pelvis or the broad ligament, the subperitoneal fat, and the deep pelvic fascia covering the obturator internus muscle. It may pass beneath the fibers of the obturator externus or take a more superficial course beneath the adductor brevis and pectineus muscles. It is accessible to palpation from the inner aspect of the thigh behind the adductor longus. The contents of the sac are always intestine.

This form of hernia occurs more frequently in women than in men, in the proportion of ninety-three to seven. It occurs in advanced life, the average age being over sixty (Macready).

Symptoms are not as a rule marked until strangulation supervenes. Many herniæ probably become strangulated as soon as protruded. Pain in the course of the obutrator nerve has been noticed in forty-two per cent. of the cases. After strangulation tenderness and pain on movement of the thigh become marked. The tumor is not so easily seen as palpated. The neck can often be felt by means of vaginal or rectal examination. The size is usually small, although cases have been seen in which the hernia was the size of an orange.

Treatment.—As mechanical treatment is impossible, all cases should be operated on unless age or disease contraindicates. Most cases are not recognized until strangulation has occurred. The mortality in strangulated cases is high—84.4 per cent. (Macready).

The protrusion can be reached from without by an incision along the border of the adductor longus and between it and the femoral vein. The pectineus and adductor brevis are thus separated, exposing the sac. Or better, especially in strangulated cases, it can be approached by the abdominal route. This allows of better treatment of the intestine, which is important since the average duration of strangulation before operation is long (seven days, according to Macready).

Ischiatic Hernia.—The few instances of this hernia have been imperfectly described. The protrusion escapes at the great sacrosciatic foramen either above or below the pyriformis muscle. Of seventeen cases collected by Macready the hernia appeared in seven in infancy or at birth. The sexes seem to be equally affected. The contents may consist of intestine, omentum, or some of the pelvic organs as the ovary or bladder. The hernia is usually small, but may extend into the thigh below the glutei or pass over the trochanter toward the groin.

It may be confounded with cysts, abscesses, new growths, or hematoma.

Treatment. –The abdominal route or a combined operation would probably be the best way of attacking this variety.

Hernia of the Pelvic Outlet.—This group comprises several varieties in which the abdominal contents escape through the floor of the pelvis. They are much more common in the female. In the male the hernia is into the ischiorectal fossa or the perineum. In the female it may be into the ischiorectal fossa, the vagina, or the labium majus. They are named from their superficial location, *ischiorectal*, *perineal*, *vaginal*, and *pudendal* or *labial herniæ*. Very few have been dissected, so their deep relations are not understood. In some cases the protrusion has occurred at the rectovesical pouch and in others at the pouch of Douglas. These herniæ are usually small, but may reach enormous proportions containing nearly the whole of the abdominal contents. As a rule they are easy of diagnosis, but a vaginal hernia may be mistaken for a fibroid, polypus, cystocele, or abscess. They seldom become strangulated. Many cases can be treated with a pessary or special truss, although some surgeons advise operation in all cases.

Varieties Depending upon Nature of Contents. —*Vesical Hernia.* The bladder may be protruded through a hernial opening. The condition is four times more common in inguinal than in femoral hernia, and very rare in other varieties of hernia, although it has been observed in ventral and in pelvic herniæ. It is most common in elderly males.

Laxity of the tissues, the pull of the hernia on the peritoneum, and distention of the bladder have been advanced as causes.

Three anatomical varieties are recognized: 1. Extraperitoneal, in which the bladder protrudes alongside of the sac of an ordinary hernia or independent of any sac. 2. Intraperitoneal, in which the bladder appears in the sac covered with peritoneum. 3. Paraperitoneal, in which a portion of bladder only is covered with the peritoneum of the sac. The latter form is the most common.

Of 192 cases collected by Cheesman[45] up to 1901, symptoms were noted in 30. The most constant symptom is the presence of a hernial tumor which disappears on micturition, or pressure upon which causes a desire to urinate or even expels urine from the urethra.

The chief importance of the condition lies in the danger of wounding the bladder in an operation for radical cure. Of the 192 cases quoted, in 47 the bladder was recognized during operation and avoided, and in 93 cases it was wounded, chiefly unintentionally. The presence of the bladder may be suspected if there be an undue amount of fat at the neck of the sac, or if muscle fibers are seen. It may be identified by the passage of a sound in the bladder or by a feeling as of two surfaces rubbing together produced by grasping the mass.

Treatment.—If the bladder is wounded it should be sutured with catgut, preferably in two rows. Catheterization should be frequently performed or a catheter may be left in the urethra for two or three days. The wound should be drained, and if no leakage occurs, the final steps of the radical cure can be completed in a few days. Fifty-five of the ninety-three cases collected by Cheesman were treated by suture, with a mortality of 20 per cent. There was a total mortality of 25 in the 93 cases, but Cheesman attributes the fatal result in 9 cases only to the bladder injury *per se*, a mortality of about 10 per cent.

Hernia of the Large Intestine.—The sigmoid flexure, cecum, or a portion of the transverse colon may be found in the sac of a hernia.

Especial interest is centered in the cases in which the sigmoid or cecum is found in the sac of an inguinal or femoral hernia. When the protruded part has a free mesentery the cases do not differ materially from other enteroceles, but in a certain number the bowel is only partially covered with peritoneum, so that a portion of gut is outside of the sac. This condition is known as *slipped* or *sliding hernia; hernie par glissement* of the French.

According to Coley,[18] sliding herniæ occur as often in children as in adults, although the general belief is that they are more common in middle-aged or elderly males. However, statistics on this point as yet are insufficient. The sliding form is more common in inguinal hernia and when the protrusion is on the right side.

Unless the condition is recognized during the operation the intestine is very liable to be injured. Furthermore reduction is often difficult. The writer has found in his experience that the gut is generally loosely attached to the abdominal wall and can be pushed back *en masse*. Attempts to fashion a peritoneal coat for the bowel should not be made. The redundant sac should be sutured. It will rarely or never be necessary to resect the bowel as has been done by some.

Relapses are more common in these than in other forms of inguinal hernia, for the reasons that the neck of the protrusion is generally very large, and that it cannot be tied off flush with the abdominal wall. Transplantation of the rectus should help in these cases. The most recent and complete description of sliding hernia is by Moschcowitz.[46]

Hernia of the Appendix Vermiformis.—The appendix is not uncommonly found in right inguinal or femoral hernia. It may occur alone in the sac, more commonly in femoral hernia. The cases of especial interest are those in which the appendix becomes inflamed (appendicitis in a hernial sac). These cases simulate strangulation and can be differentiated only by the absence of the signs of obstruction. The condition is not common. Wood[47] has compiled notes of 100 cases.

Hernia of the Ovary.—On account of error in development the ovary may descend alongside the canal of Nuck into the inguinal canal or even the labium. This condition, *ectopia of the ovary*, is found more commonly in young children, and there is reason to believe that in many cases the organ returns at or before puberty to its normal position. According to Macready,[1] hernia of the ovary occurs in 1.2 per cent. of inguinal herniæ in the female. When there is double ectopia the uterus and tubes are as a rule defective in development, and they may be so in single ectopia. In some cases the tube and even the uterus may be drawn into the sac. Associated with this condition there may or may not be a hernia of the intestine, either congenital into the open canal of Nuck, or into another sac. In most cases the canal of Nuck is open.

In some cases the ovary is reducible and the hernia can then be treated by truss. Other cases should be treated by operation, the ovary being excised or, if its connection can be preserved, returned to the abdomen.

Cases in which the ovary is found with other viscera in otherwise ordinary herniæ are of no particular interest. Heineck[48] has made an extended résumé of this subject.

Diaphragmatic Hernia.—A protrusion of the abdominal viscera may take place through a wound or through portions of the diaphragm that are deficient. The places where the muscular fibers of the diaphragm are normally deficient are "Larrey's space" between the costal and sternal attachments, and on either side at the lateral portions of the external arched ligaments. A hernia may occur through the esophageal opening. Finally there may be a congenital defect in the diaphragm. These herniæ are classed as true when the peritoneal sac is present and as false when the viscera lie free in the pleural cavity. The latter form is more common, since the hernia is generally due to trauma.

The protrusion usually occurs on the left side on account of the position of the liver. Varying amounts of the abdominal contents may escape into the thorax. The stomach is the most commonly protruded, although any of the viscera with the exception of the genito-urinary organs may be displaced into the thorax.

The symptoms may be those of pneumothorax, the heart may be displaced, there may be marked interference with respiration, and there may be symptoms of strangulation. For an extended description of diaphragmatic hernia consult Scudder,[49] Salomoni[50] and Giffin.[51]

Mechanical Treatment.—The mechanical treatment of hernia consists in the application of a truss or apparatus to the protrusion. With few exceptions this treatment can be applied only to reducible hernia. Special forms of apparatus have been devised for some forms of reducible hernia in which operation is contra-

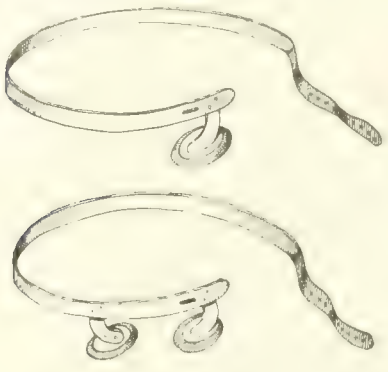


Fig. 3162.—Single and Double Knight Trusses.

indicated; such, for instance, is the hinged cup truss for irreducible inguinal hernia.

For inguinal and femoral hernia three principal varieties of truss are used, namely the "cross body" or Knight truss (Fig. 3162), the frame or Hood truss (Fig. 3163), and the "same side" or French truss.

The chief desiderata in a truss are perfect fit, so that pressure is evenly made on all parts of the pelvis with which it comes in contact; a good spring, the best material being steel, as it combines lightness and durability; and a pad so arranged as to make pressure at the point of exit of the hernia, *i.e.* over the internal ring in inguinal hernia, and not on the pubic bone.

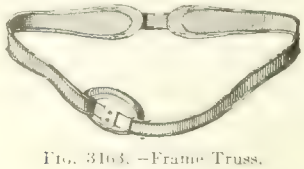


Fig. 3163.—Frame Truss.

The pad is best made of smooth non-absorbent material as celluloid, hard-rubber, or wood. Sometimes a pad of wood covered with leather is serviceable.

When the pressure of a hard pad is unbearable, as it sometimes is in large herniæ, the elastic water pad can be used.

In adults trusses may be removed at night, as a cure is rarely attainable, but in children, in whom the descent of the hernia would preclude all chance for a cure, the truss should be worn day and night.

It is impossible in so brief an article to give the indications for the use of different trusses, and the methods of application. These points are largely learned by practical experience.

For umbilical hernia special forms of truss have been devised, but for most cases the best apparatus is a well-fitting abdominal support with a pad of suitable size to control the protrusion and of a thickness equal to that of the subcutaneous fat.

For umbilical hernia in children a broad strap of zinc oxide rubber plaster with a wooden button over the hernia makes a very efficient apparatus.

Results of Mechanical Treatment.—Inguinal Hernia. According to Coley by far the greater majority of cures are obtained in the first year of life. The best results are obtained with the spring truss in infancy, it being far superior to the "worsted" or "skein" truss.

In children cures are more often obtained in girls than in boys, the reverse being true in adults. About two-thirds of the cases of inguinal hernia can be cured in childhood. Cures are seldom attained in patients over five years of age.

Femoral Hernia is practically incurable by mechanical means.

Umbilical Hernia. In the infantile form a cure is nearly always obtained. In adults the most that can be hoped for is limitation of the size of the protrusion.

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Heroine, diacetyl-morphine $[C_{17}H_{17}.(CH_3CO)_2.NO_3]$, is one of the group of morphine compounds to which belong codeine, dionine, and peronine. It occurs as an odorless and slightly bitter, white, crystal-

line powder, insoluble in water, and soluble in dilute acids. The hydrochloride, the salt generally used, is freely soluble in water and alcohol, insoluble in ether, and incompatible with alkalies.

Experiments show that heroine is not absorbed by the unbroken skin, and has but slight effect on mucous membranes. It tends to cause dryness of the throat and slight irritation of the gastrointestinal tract as manifested by nausea, vomiting, and diarrhea. These effects are, however, uncommon. In therapeutic doses the circulation is unaffected, though heart failure may follow a large dose. The main action of the drug is upon the respiratory organs, as it tends to diminish bronchial secretion, while it slows and increases the depth and strength of respiration. Dreser demonstrated that a smaller amount of oxygen was used by the system and less carbon dioxide eliminated; in other words, the metabolic processes were retarded. On account of this diminished tissue activity there is a slight temporary lowering of body temperature. In very few cases has any hypnotic or analgesic effect been noted. Heroine is a very powerful remedy, the maximum dose being one-twentieth that of codeine. Observers agree that the dose of 0.01 gram (gr. $\frac{1}{6}$) should not be exceeded. Though not very common, cases with unpleasant sequelæ are met with by every user of the drug. Therapeutic doses have been followed by dryness and irritation of the pharynx, nausea, vomiting, constipation, diarrhea, languor, and, rarely, excitement or delirium. In one case the patient always became greatly excited after a dose of morphine or heroine, but never after codeine. Some writers advise adding potassium iodide to prevent dryness of the throat, and cascara or calomel for the constipation. A dose of 0.015 gram (gr. $\frac{1}{4}$) given by mistake to an asthmatic patient was followed by prostration, cyanosis, amaurosis, restlessness, pulse of 40, feeble heart action, spasm of the legs, persistent nausea, subnormal temperature, and a semi-comatose condition.

Among the large number of published reports most authorities agree that heroine is valuable in the treatment of bronchitis, bronchial asthma, pulmonary tuberculosis, and whooping-cough, while opinions differ as to its efficacy in neuralgia, angina pectoris, cardiac dyspnea, etc. Bastedo used it in over one hundred cases of tuberculosis, and found it of distinct use, but inferior to codeine in allaying the cough, irritability, and pain, and in promoting sleep. Heroine had little, if any, effect on the pain, dyspnea, or night sweats. Loewenthal employs it in infantile diarrhea and colic, the maximum dose for a child of one month being 0.0002 gram (gr. $\frac{1}{3}\frac{1}{0}\frac{1}{0}$), of six months 0.00027 gram (gr. $\frac{1}{2}\frac{1}{5}\frac{1}{0}$), and of five years 0.0024 gram (gr. $\frac{1}{2}\frac{1}{5}$). Unfortunately, heroine produces a "drug habit," which is not easy to cure.

W. A. Bastedo.
R. J. E. Scott.

Herophilus.—Born in Chalcedon, Asia Minor, about 344 years before the birth of Christ. Our knowledge of Herophilus is based entirely upon the statements relating to him that are to be found in the writings of Galen. He was the head of a somewhat celebrated school of medicine, and was the disciple of Praxagoras of Cos. He lived at Alexandria in the Museum that was founded and kept up by the Ptolemies for the glory and advancement of the Sciences. Both Celsus and Tertullian accuse Herophilus of having dissected human beings while they were still alive, but it really seems absurd to entertain such an accusation seriously. There are reasons for believing that Herophilus and Erasistratus were the very first to dissect human cadavers, and it is highly probable that such a performance appeared so novel and so objectionable to many of their contemporaries that they did not hesitate to exaggerate and distort the facts in such a manner as to make these two men appear to have been guilty of horrible profanation. Furthermore, there is scarcely any doubt that Herophilus, by means of such dissections, acquired much knowledge regarding the nervous system, and that many of the terms now employed for designating the different parts of this system were first given to them by him. He called attention to the existence of the dural sinuses and noted their confluence, which he compared to a wine-press, the "Torcular Herophili"; he also described the fourth ventricle, and gave descriptions of and names to the prostate gland, the hyoid bone, and the duodenum. A. H. B.

Herpes.—The term herpes (from ἕρπειν, to creep), formerly employed to designate a large number of diseases of the skin of varying etiology, is restricted at the present time to a class of affections whose distinguishing clinical feature is a grouped vesicular eruption seated upon an inflamed and slightly swollen base. If the term is used in this restricted sense there are practically but two varieties of the disease, viz., simple herpes, of which there are a number of regional forms which differ but little from one another in their clinical characters; and herpes zoster, which clinically and etiologically is quite distinct from the first-named variety. The herpes iris of some authors properly belongs to erythema multiforme; herpes gestationis is one of the forms of the dermatitis herpetiformis of Duhring; while the herpes circinatus and herpes tonsurans of some continental authors are parasitic affections, much more frequently characterized by erythematous and squamous eruptions than by vesicular lesions.

The appearance of the herpetic eruption is preceded for a variable period, usually short, by a sensation of burning, pricking, or slight itching; after a few hours an erythematous, slightly swollen patch appears upon which small papules arise which are speedily transformed into a group of vesicles with clear serous contents, each group containing from three or four to a dozen or more lesions. The vesicles, at first discrete, later become more or less confluent through increase in size, often forming small blebs. After from twenty-four to forty-eight hours the contents of the vesicles become cloudy, then purulent, and yellow or brown crusts form, which after a week or ten days fall off, leaving a slightly reddened patch which lasts but a few days and disappears without leaving any trace of its existence.

Herpes Simplex.—In the great majority of cases the eruption of simple herpes is situated upon the face, usually the lower half; hence it is also spoken of as facial herpes. The parts of the face most frequently attacked are, in the order of frequency, the lips, the lower oftener than the upper lip, the cheeks, and the alæ of the nose. It sometimes occurs upon the external ear and still less frequently upon other parts of the cutaneous surface. It usually begins quite abruptly with a sensation of heat or itching; the skin over a limited area becomes red and slightly swollen, and upon this area a group of small papules appear which in a short time become clear vesicles. The vesicles, discrete in the beginning, enlarge slightly for a short time after their appearance and frequently coalesce, forming blebs that vary in size from that of a pea to that of a dime; but when the lesions are very small and few in number, they usually remain discrete. At the end of a day or two the contents of the vesicles become purulent; they then dry up, forming yellow or brown crusts, which fall off in a few days more, leaving slightly red, or occasionally transiently pigmented stains, the entire attack lasting from four or five days to two weeks.

The eruption is not always limited to the skin, but may appear upon the adjoining mucous membranes, even the larynx in rare instances being invaded. When the eruption occurs upon mucous surfaces it

presents marked differences from that upon the skin. Owing to the moisture with which the affected parts are constantly bathed, the vesicles appear as white opaque elevations which are soon transformed into shallow erosions through spontaneous rupture. Herpes of the mucous membranes is, in the great majority of cases, associated with similar lesions upon the skin, although pharyngeal herpes may occur alone; the mucous membranes attacked being usually those of the lips, the cheeks, and the pharynx.

In a considerable proportion of cases the appearance of the eruption is preceded or accompanied by sensations of chilliness and some elevation of temperature; hence the popular terms "cold sore," "fever blister," applied to these eruptions.

In many individuals there is a marked tendency to recurrences, and this continues for years, the eruption appearing often in the same locality with the slightest derangement of the general health, or following slight irritations of the skin.

Although, as a rule, there are usually but two or three groups of vesicles, and often but one, each containing a moderate number of lesions, it happens in rare instances that the eruption is much more extensive, covering, it may be, almost the entire cutaneous surface. Such extensive cases have been reported chiefly by French observers, Rendu having only recently described a case of generalized herpes produced by the ingestion of uncooked shell-fish. It seems to me, however, that such eruptions are very closely allied to, if not actually examples of, bullous erythema multiforme, rather than true herpes.

Facial herpes frequently occurs in febrile diseases of various kinds, such as pneumonia, in which it is quite common, in typhoid fever, in the malarial fevers, and in cerebrospinal meningitis; a favorable prognostic significance being attributed to it. In the malarial fevers it may occur with each febrile paroxysm, or in exceptional cases it may replace it, as has been noted by several writers.

Under the name herpetic fever, various authors have from time to time described an endemic affection in which, after marked constitutional disturbances, such as chills and elevation of temperature, an herpetic eruption appears upon the face or other parts of the cutaneous surface. A remarkable endemic of this kind has been reported by Savage in which, in an institution for boys, thirty-nine cases of herpes occurred. In this outbreak the eruption was preceded by chills, nausea, and elevation of temperature varying from 102° to 104.5° F., and was accompanied by sore throat and swollen glands, the attack lasting four days.

Herpes Genitalis.—The genital organs of both sexes are frequently the seat of herpes, the eruption occurring, in men, upon the margin of the prepuce or upon its inner mucous surface (herpes præputialis, herpes progenitalis), upon the glans, and, much less frequently, upon the skin of the shaft of the penis; in women the parts affected are the vulva, the mucous surfaces of the labia majora, the labia minora, the clitoris and the prepuce, and the mucous membrane about the meatus urinarius. The appearance of the eruption is preceded by more or less burning or stinging, which is shortly followed by redness, edema, and the formation of groups of vesicles which are usually quite small. When the skin surfaces are attacked the vesicles after a day or two dry up into brownish crusts which fall at the end of a week, leaving a slightly reddened, or, it may be, pigmented patch. When the eruption occurs upon the mucous surfaces, as the inner side of the prepuce, the glans, or the labia minora, the vesicles rupture almost immediately, forming shallow erosions, the bottoms of which are often covered with a whitish or gray membrane. Occasionally the eruption appears in successive crops separated by intervals of some hours or a day or two, thus prolonging the attack greatly. Fournier has observed a case in which the disease was thus prolonged for five weeks; but this is altogether exceptional. When the affected parts are irritated by violence or by the application of caustics, as not infrequently happens, the inflammation may be considerable and may be attended by marked induration of the base of the vesicles; this induration being especially apt to occur upon the glans in the region of the sulcus. In such cases the glands in the groin may be noticeably swollen. In rare cases the eruption occurs upon the urethral mucous membrane, giving rise to ardor urinæ and, in the male, to a serous discharge. Although, as a rule, subjective symptoms are limited to slight burning or itching, it occasionally happens that the pain is severe, even neuralgic in character.

In women the eruption is sometimes quite extensive, covering the cutaneous surface of the vulva, and the labia majora and minora with numerous groups of vesicles and erosions, and at times extending down upon the inner surface of the thighs. The pain and burning in such cases are severe, and with the marked swelling which is commonly present walking is difficult and at times impossible. Superficial ulceration may occur with the formation of vegetations, producing an appearance much like that of a syphilitic mucous patch; indeed, according to Fournier, it is sometimes impossible to make a positive differential diagnosis until after the lapse of a considerable period of time.

Of all the forms of herpes the genital is most apt to recur, the interval between the attacks varying from a few weeks to several months. In a considerable proportion of cases each coitus in the male and each menstrual period in the female is followed by an attack, the recurrences continuing for years. On the other hand there may be but a single attack.

Simple herpes is in many cases, no doubt, a local manifestation of a general toxemia. Its frequent association with such general diseases as pneumonia, typhoid and the malarial fevers, epidemic cerebrospinal meningitis, and other maladies of an infectious nature, lends strong support to such a view of its etiology. Although probably not a common cause, certain articles of food may produce an attack in predisposed individuals; in a gentleman under my own observation an attack of labial herpes invariably followed the eating of cheese. In a considerable proportion of cases, however, it must be regarded as due to local conditions associated with a special predisposition. In genital herpes excessive irritations and congestions, physiological or pathological, such as coitus and the menstrual period, play important rôles in the production of the affection. Uncleanliness and previous venereal disease are potent etiological factors. As Unna and Fournier have pointed out, prostitutes are especially liable to suffer from herpes of the genitalia.

The herpetic eruption is the result of a peripheral neuritis of an acute transitory character, the consequence of a direct or reflex irritation of the terminal nerve branches distributed to the skin. Unna, who had the opportunity to examine lesions from three cases of genital herpes, found a fibrinous inflammation of the epidermis, the primary changes affecting the more superficial prickle cells. The entire epidermis was lifted from the papillary layer of the corium, forming a blister whose walls and contents had undergone coagulation necrosis. Beneath the vesicle the entire cutis was edematous and the blood and lymph vessels were markedly dilated. A striking histopathological difference between the vesicle of simple herpes and that of herpes zoster is the absence of the so-called "ballooning" of the epithelial cells in the former.

The *diagnosis* of simple herpes is usually made without the slightest difficulty. The purely vesicular character of the lesions, the grouped arrangement of the eruption, its localization upon the face, in most cases about the mouth, or upon the genitalia, and the

acute course of the disease are features so characteristic that there is little chance for error. When, however, the eruption is seated upon the mucous membranes, particularly those of the genitalia, the erosions which follow the vesicles may be mistaken for venereal ulcers or the initial lesion of syphilis. The herpetic lesion is superficial and does not tend to extend like the chancroid; it exudes an abundance of serum instead of pus, which, as Leloir has pointed out, may be much increased by squeezing the lesion between the thumb and finger; its borders are apt to present a festooned or polycyclic outline; and lastly, there are often groups of well-defined vesicles in the neighborhood. It is to be distinguished from the initial lesion of syphilis by its brief duration and the absence of the peculiar induration characteristic of the chancre. It should not be forgotten, however, that the herpetic lesion, under the influence of irritants, may present an indurated base much like that seen in the chancre, and that in such cases there may be swelling of the inguinal glands. Fournier has called attention to the fact that the chancre may be preceded by herpes; and it is always wise, in view of the very serious results which may follow an error in diagnosis, to be very guarded in expressing an opinion in doubtful cases until sufficient time has elapsed to make the diagnosis certain.

In the *treatment* of simple herpes all irritant applications should be avoided. Frequent applications of ninety-five-per-cent. alcohol in the early stages of the eruption will sometimes partially abort it. If there is marked burning, a saturated aqueous solution of boric acid will be found very useful in relieving this symptom; or a solution of resorcin, from eight to ten grains to the ounce of water, may be even more effective. A lotion containing twenty grains each of sulphate of zinc and sulphide of potassium, as recommended by Duhring, is also a useful remedy.

In genital herpes the parts should be kept scrupulously clean, and nothing better for this purpose can be used than a saturated solution of boric acid, which should be freely and frequently mopped upon the affected parts. When the mucous surfaces are the seat of the eruption, they should be kept apart by pieces of gauze wet with the boric acid solution; or, after careful cleansing, they may be covered with a dusting powder of talc and oxide of zinc, to which, if there is annoying pain, from ten to twenty per cent. of acetanilid may be added, or the acetanilid may be used alone. The resorcin lotion above referred to will often be found a very soothing and cleansing application. Lotio nigra may be employed in many cases with good results. If suppuration occurs, weak solutions of bichloride of mercury should be applied several times a day, but this remedy must be used cautiously as it sometimes proves irritating. As a preventive measure, circumcision has been recommended in recurrent herpes genitalis; it is, however, an uncertain remedy. Arsenic given internally for a considerable period exercises a decided influence in preventing recurrences in many cases, and should always be tried when other remedies have failed.

MILTON B. HARTZELL.

Herpes Zoster.—Herpes zoster, also known as zona, zoster, shingles—this last probably being a corruption of the Latin *cingulum*—names all having reference to the girdle-like arrangement which the eruption often exhibits, usually begins with pain, commonly of a neuralgic character, varying in degree from mere discomfort and soreness to the severest neuralgia, and situated in the regions presently to be the seat of the herpetic eruption. Exceptionally in the beginning of the attack there is some elevation of temperature with slight malaise. After a prodromal period, varying from a few hours to several days, groups of papules seated upon a reddened and slightly swollen base appear in the painful areas, and in the course of a few hours they become vesicles with transparent contents. With the appearance of the eruption the pain may diminish, but there are frequent exceptions to this rule. The vesicles, for the most part discrete, tense, and showing no tendency to spontaneous rupture, vary in size from a hemp seed to a large pea, and are arranged in variously sized groups from one or two to a dozen or more in number, separated by areas of normal skin, and situated over the distribution of some nerve usually at points where branches are given off to the skin. The several groups of vesicles do not appear simultaneously, but new ones continue to form for some days, the last-formed groups often containing many papules which do not develop into vesicles, and imperfectly developed vesicles. After a day or two the vesicular contents become turbid, then purulent, and later brown or black crusts form which fall off at the end of from ten days to two weeks, leaving transiently hyperemic patches, or slight pigmentation, and frequently permanent scars. The duration of the entire attack is from ten days to three weeks; but when the inflammation is unusually severe, or when complications, such as suppuration and gangrene, occur, it may last much longer.

The amount of pain present varies within wide limits. In children and young adults it is often entirely absent, or so slight as to cause little or no complaint; but in elderly subjects it is commonly severe, often demanding large doses of powerful narcotics for its relief, and sometimes continuing for weeks or even months and years.

In an overwhelming majority of the cases the eruption is limited to one side of the body, although it is not at all uncommon to see a group of vesicles extend some distance beyond the middle line. While it may occur over the course of any peripheral nerve, it is much more frequently situated upon the trunk than upon the extremities. In one hundred cases in which the location of the eruption was specially noted by Crocker, it was observed to occur upon the trunk fifty-four times.

Variations from the ordinary type of zoster occur in a small proportion of cases. The vesicles may be filled with blood instead of serum, giving the eruption a blue or black appearance. In this variety, known as *zoster hæmorrhagicus*, the pain is as a rule extremely severe, and ulceration more or less deep is prone to occur.

In cases of unusual severity suppuration may take place, and in rare instances gangrene of the skin occurs, either after the appearance of the vesicles or before these have had time to develop. As the result of the severe and at times deep-seated inflammation, extensive and indelible scarring follows, which later may become the seat of keloid.

As *zoster gangrænosus hystericus* Kaposi has described an atypical form of zoster that occurs in hysterical women. This variety of the malady is characterized by repeated attacks separated by intervals of a few weeks or some months, the eruption being unilateral or bilateral. Gangrene of the skin at the base of the vesicles occurs, and keloid-like cicatrices follow. This disease is certainly closely related to, if not identical with, the multiple hysterical gangrene of the skin of other authors; and while it is mentioned here, I think it is doubtful if it properly belongs to herpes zoster.

While almost invariably limited to one side of the body, the eruption may be bilateral. According to Hyde, bilateral zoster is most apt to be seen in those suffering from syphilis or in those taking arsenic.

Colombini has reported a case in which the eruption was universal, groups of vesicles occurring over the branches of all the cutaneous nerves. The disease in this instance was most likely of malarial origin, as the patient had had repeated attacks of malarial fever, and the eruption appeared shortly after one of them.

Second attacks of zoster are rare, although not so

infrequent as formerly supposed. In recurrent zoster the same region may be affected several times, or new regions may be invaded with each new attack. Recurrences are most likely to be observed in those cases in which the disease is of traumatic origin; as in one under my observation some years ago in which the sciatic nerve was injured by a fracture of the femur. In this case there were many attacks preceded and accompanied by severe pain, most of them in the region of the distribution of the sciatic nerve and its branches. While the pain usually diminishes with the appearance of the eruption and ceases entirely with its complete involution, it may persist for a considerable period, especially in elderly subjects, after all other evidences of the disease have disappeared. Other sequelæ are local paralyses, and various disturbances of sensation, either alone or associated with trophic changes.

The principal local varieties of herpes zoster, named according to the region in which the eruption is situated, are Z. capillitii, Z. frontalis, Z. facialis, Z. ophthalmicus, Z. colli, Z. brachialis, Z. pectoralis, Z. abdominalis, Z. femoralis. In these several local varieties the disease presents practically the same clinical features, particularly so far as the eruption is concerned, but it may vary considerably as to extent and the severity of the inflammation and pain which accompany it.

In Z. frontalis the eruption follows the distribution of the supraorbital branch of the fifth pair, extending over the lid, one-half the forehead, and up into the scalp. This form is sometimes followed by marked scarring resembling the pits produced by variola.

In Z. ophthalmicus, in which the branches of the fifth pair distributed to the eye are affected, the pain is often of the severest character, and the various structures of the eye may be inflamed, the inflammation being in rare cases so severe as to cause destruction of this organ. Fatal meningitis has been known to result in this variety of zoster.

In Z. facialis the second branch of the fifth pair is concerned, the eruption occurring on the cheek, the side of the nose, and one-half of the upper lip. In

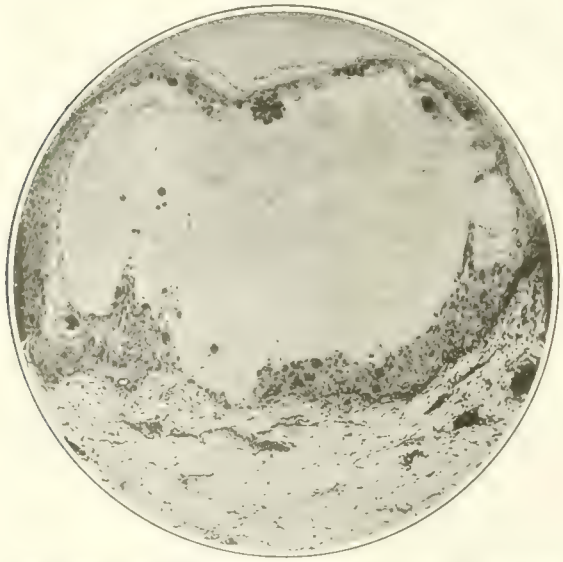

Fig. 3164.—Vesicle of Zoster. Upon the bottom of the vesicle are numerous cells which have undergone alteration like that shown in Fig. 3165. (Author's own case.)

exceptional cases it also occurs upon the mucous membranes of the cheek and pharynx. Loss of the teeth and necrosis of the jaw have been noted as rare complications.

The supraspinous portion of the scapula and the upper arm are the regions affected in Z. brachialis. The forearm and the fingers are not often involved. This is usually a mild form of the malady.

Z. pectoralis is the variety oftenest seen, and the one from which the disease gets its various names

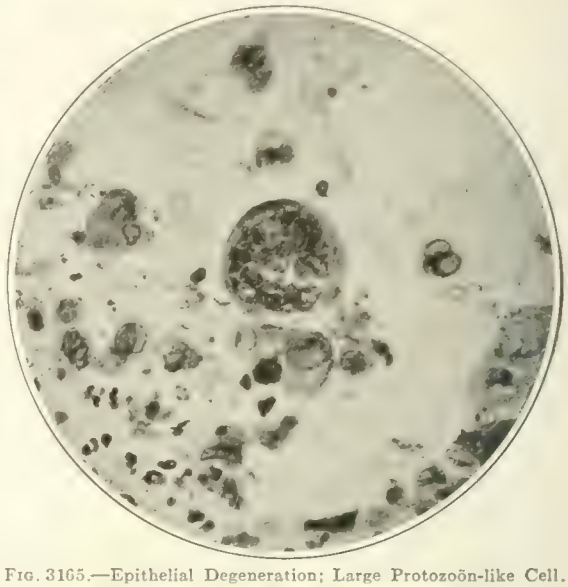

Fig. 3165.—Epithelial Degeneration; Large Protozoön-like Cell. (From author's own case of herpes zoster.)

signifying a girdle. Groups of vesicles extend from the spine forward to the sternum. In many cases the eruption consists of but two or three groups, one close to the spine, a second in the axillary line, and a third, often composed of imperfectly developed lesions, near the anterior middle line. In severe cases the groups of vesicles may coalesce, forming a continuous half-girdle. In this variety of zoster the pain which sometimes precedes the appearance of the eruption may be mistaken for a pleurisy.

In Z. femoralis the eruption is situated upon the anterior surface of the thighs, the external genitalia, and upon the buttocks. The legs and feet are only rarely attacked.

Etiology.—Zoster occurs much more frequently in the young than in the old, but old age is by no means exempt. In three-fourths of the cases observed by Crocker the patients were under twenty years of age. Although infrequent in infancy cases have been reported in infants from four days to several months old. The sexes appear to be equally liable. Cold, damp, and other climatic influences seem to play some part in its production since it occurs most frequently in winter and spring.

It sometimes occurs in connection with such diseases as influenza, malaria, and tuberculosis. Winfield has reported a number of cases in which the presence of the plasmodium malariæ was demonstrated; and it has been observed often enough in the subjects of tuberculosis to suggest the possibility of a causal relationship between the two maladies.

As was first pointed out by Hutchinson, and afterward confirmed by other observers, arsenic when given in large quantities for a prolonged period may produce zoster by setting up a neuritis. Other toxic substances, such as carbonic oxide gas, have also produced the disease. In a considerable number of instances the eruption has been observed to follow injuries to nerves. Occasionally it seems to be of reflex origin, as is shown by a case reported by Jewel in which a crural zoster resulted from disease of the uterus; and in other cases it has seemed to be due to irritation in the ali-

mentary canal caused by the presence of tapeworm. Within the past few years Bittorf, Rosenberg, and others have reported cases associated with renal colic the result of hydronephrosis or nephrolithiasis. Lastly, it is very probable that in a considerable proportion of cases it is the result of a specific infection, although the infectious agent is as yet unknown. Its occurrence in epidemics, its undoubted occasional contagiousness, its self-limited course, and the rarity of second attacks are features of the malady which are strongly in favor of such a view. From the foregoing brief summary it is evident that there is no one cause of herpes zoster, but that it may be produced by any agent capable of setting up a neuritis.

Pathology and Pathological Anatomy.—Proof of the neuritic character of the disease was first furnished by Baerensprung, who found that there was inflammation of the ganglia and the nerves distributed to the area occupied by the eruption. The ganglia do not always share in the inflammatory process, as Baerensprung supposed, but the inflammation is sometimes limited to the peripheral parts of the nerve. The pathological alteration of the nerve is not always of an inflammatory character, but may be the result of hemorrhage, the pressure of new growths, or traumatism.

The zoster vesicle lies deeply within the epidermis, the bottom being formed by the papillary layer of the corium upon which lie masses of altered epithelium. The most striking feature is the peculiar alteration which many of the epithelial cells have undergone, by which they have been transformed into bodies resembling more or less closely protozoa. These bodies were regarded by Pfeiffer, who was one of the first to describe them, as parasites, and were believed by him to be the cause of the disease; but the later investigations of Unna, Torok, myself, and others have clearly demonstrated their epithelial character. These altered cells are often enormous in size, round, oval, or balloon-shaped, with a double-contoured wall or capsule within which are from two to a dozen or more large round and oval nuclei which often present a peculiar beaded limiting membrane. The cavity of the vesicle contains a few free epithelial cells, a small number of leucocytes, and fibrin. The papillæ and that part of the corium immediately beneath the papillary layer are abundantly infiltrated with leucocytes, and there is dilatation of the blood-vessels.

Diagnosis.—The clinical features of zoster are, in the great majority of cases, so well defined that the diagnosis is usually easily made. The two diseases with which it is most likely to be confounded are vesicular eczema and simple herpes.

It may be distinguished from eczema by the grouping of the vesicles over the course of known nerves, by the accompanying neuralgia, by the absence of itching and discharge, and by the vesicles, unlike those of eczema, showing no tendency to spontaneous rupture.

It differs from simple herpes by its unilateral distribution, by the pain which precedes and accompanies the eruption, and by the infrequency of second attacks. Simple herpes is most apt to occur about the mouth and upon the genitalia, regions seldom invaded by zoster.

Prognosis.—The prognosis is in most cases favorable, the disease usually terminating in from ten days to three weeks. In severe attacks, however, or when ulceration, deep-seated inflammation, or gangrene occurs, the duration may be greatly prolonged beyond the usual period. In elderly subjects, less frequently in the young, persistent neuralgia of a severe type or paresthesia may follow, lasting for months or years. In exceptionally severe cases of ophthalmic zoster disfiguring, scarring, loss of an eye, and even death may result.

Treatment.—In mild cases of herpes zoster only the simplest treatment is required. The vesicles should be protected from the friction of the clothing by covering them with two or three thicknesses of gauze or a thin layer of absorbent cotton, having first freely applied a simple dusting powder, such as equal parts of starch and oxide of zinc, to which, if there is burning or pain, camphor or morphine may be added. Internal remedies administered with the view of aborting or controlling the eruption are of more than doubtful efficacy. Phosphide of zinc, in doses of from one-sixth to one-third of a grain given every three hours, is recommended by Thompson and Bulkley for the relief of the pain and the control of the eruption, but other observers have not found it reliable. In cases in which the pain is severe, antipyrin, phenacetin, or acetanilid may be given in doses of from five to eight grains every three or four hours; when these fail to afford relief morphine, given hypodermatically, may be employed. Locally frequent application of ninety-five-per-cent. alcohol is often very useful; or, instead of simple alcohol, alcoholic solutions of resorcin fifteen grains to the ounce, or a solution of carbolic acid five to ten grains to the ounce, or of menthol ten grains to the ounce, may be used. Such lotions should be mopped on gently every three or four hours with a soft cloth, care being taken not to rupture the vesicles. Duhring specially recommends a lotion containing from twenty to sixty grains each of sulphate of zinc and sulphide of potassium to the ounce of water; he finds it very useful in relieving pain and drying up the eruption. Collodion, either alone or with one or two grains of morphine to the ounce added, may be painted over the eruption for the purpose of favoring its absorption and alleviating the pain. For the relief of persistent neuralgia, galvanism is perhaps the most useful remedy, mild currents being more useful than strong ones. Crocker finds repeated blistering over the root of the affected nerve very efficacious in some cases. An abundance of easily digested, nutritious food, and cod-liver oil are also indicated.

MILTON B. HARTZELL.

Herpetomonas.—*Leptomonas.* A genus of flagellate protozoans. These animals are parasitic in insects and other invertebrates, and are of interest because they resemble developmental stages in certain more specialized flagellates. See *Protozoa.*

A. S. P.

Herpetomonidæ.—A family of flagellate protozoans, which is of particular interest because its forms show a transition from a simple structure to that characteristic of trypanosomes. Important genera are: *Herpetomonas,* with a single flagellum and no undulating membrane; *Crithidia,* with a poorly developed undulatory membrane; *Leishmania,* and *Babesia.* All are parisitic. See *Protozoa.* A. S. P.

de Hery, Thierry.—A barber-surgeon who, during the sixteenth century, was considered a great authority on all questions relating to syphilis. He was born at Paris and studied medicine in that city under Jacques Houllier and Antoine Saillard, both of them members of the Faculty of Medicine. At that period (about 1530) all barber-surgeons were obliged, in order to qualify as masters of surgery, to devote four years of time to preparatory surgical training under the guidance of the Faculty. Barber-surgeons, therefore, at least those of Paris, were not during the sixteenth century all ignoramuses and charlatans, as we are apt to assume, and Thierry de Hery appears to have been one of these exceptions. In 1537 he accompanied the French army on their campaign into Italy. He visited Rome, and while there he seems to have been connected, in one capacity or another, with the Hospital of St. James, which at that period contained a large number of patients affected with syphilis. The date of de Hery's return

to Paris is not known, but it must have been a long time before 1552, the year in which he published his famous treatise on venereal disease. The story is told that when, on a certain occasion, he visited St. Denis, near Paris, he knelt in front of the statue of Charles VIII. (1470–1498). A monk who happened to be near by ventured to remind him that he must have made a mistake, as the statue did not represent one of the saints. "No father," he replied, "I know perfectly well what I am doing; Charles VIII. is a good enough saint for me, as he put thirty thousand francs into my pocket when he introduced the pox into France."

Thierry de Hery laid it down as a rule that, for the cure of a syphilitic affection, one of the three following methods would have to be employed: (1) The internal administration of the decoction of guaiac; (2) the application of a mercurial ointment or of mercurial plasters; and (3) mercurial fumigations. He insisted, however, that the employment of inunctions is the most efficacious of all these methods. He died in 1599 at an advanced age.

The title of the treatise referred to above reads as follows: "La Méthode curatoire de la maladie vénérienne, vulgairement appelée *gross-vairolle*, et de la diversité de ses symptômes," composée par Thierry de Hery, lieutenant-général du premier barbier-chirurgien du roi, à Paris, 1552. Both Ambroise Paré and Pierre Franco are said to have transferred large portions of the text of this book to their own works. A. H. B.

Heterokaryota.—*Ciliophora. Infusoria.* Protozoa which possess cilia during part or all of their life cycle. A macro- (trophic) and micronucleus (reproductive) are always present. There are two subdivisions: *Ciliata*, possessing cilia throughout life, and *Acinetaria*, having cilia in early stages which are replaced by suctorial tentacles in the adult. See *Protozoa.* A. S. P.

Heterophyes.—A genus of flukes. The cuticle has scale-like spines; the size is always small. In Egypt *H. heterophyes* is an intestinal parasite in man there and in Japan it is also found in dogs and cats. See *Trematoda.* A. S. P.

Heteroplasia.—The production of a tissue or organ in a place where it should not be is the definition usua ly given for this term. It has been applied to various tumor-like formations of the nature of hamartomas or choristomas (heteroplastic osteomas, chondromas, etc.). Schridde applies it to a class of conditions in which there is heterotopia of tissue, such as the occurrence of islands of stomach mucosa in esophagus or intestine, intestinal glands in stomach, pancreatic tissue in stomach or intestine, prickle-cells in trachea, prostate, uterus, or urethra, cervix mucosa on external os or inner surface of hymen, etc. Orth has applied the terms *alloplasia* and *dysplasia* to the class of conditions grouped by Schridde under the term heteroplasia. In such heteroplasias the heterotopic tissue is always one found normally in the organ directly bordering upon the one in which the tissue-heteroplasia occurs. It is very probable that they all represent disturbances in the course of ontogenetic differentiation; and they should therefore be regarded as congenital anomalies, and not classed with the true metaplasias. Schridde regards it as improbable that they could arise from indifferent cells that remain latent to develop later after the differentiation of the tissues of the body is completed. Such a heterochronous heteroplasia remains to be demonstrated. A. S. Warthin.

Heteroptera. A suborder of bugs in which the front pair of wings are half horny and half membranaceous, when present. The bed-bugs, *Cimicida*, the assassin bugs, *Reduviida*, and the *Lygaeida*, all attack man. See *Insects, parasitic*, and *Insects, poisonous.* A. S. P.

Heterotricha.—An order of ciliate protozoans in which some of the cilia are fused to form membranelles in connection with the oral opening. See *Protozoa.* A. S. P.

Hetol is an aqueous solution of sodium cinnamate, which has been used in cases of tuberculosis and cancer. Intravenous and intramuscular injections of the preparation have been made, and the physiological effect has been an absolute and relative polynuclear leucocytosis. It is of doubtful utility. R. J. E. Scott.

van Heurne, Jan.—Johannes Heurnius was born at Utrecht, Holland, January 25, 1543. In his early youth he was extremely backward in acquiring the foundations of an education. At the age of eleven, for example, he had barely learned to read, and by the time he reached fifteen he had not yet mastered the rules of grammar. At about this time, however, the love of work began to develop in him, and he soon made up for the time which he had lost. At the age of eighteen he was sent to the University of Louvain, to study medicine, and from there he went to Paris, where he followed most attentively the instruction of Duret. At twenty-four he visited Italy, and in 1571 he received the degree of Doctor of Medicine from the University of Pavia. He spent the last twenty years of his life at Leyden, Holland, where he occupied the Chair of Medicine in the university. He died on August 11, 1601, at the age of fifty-eight. During the years immediately preceding his death he suffered a great deal from stone in the bladder; and at the post-mortem examination eight calculi, weighing in the aggregate fourteen ounces, were found in that organ.

Heurnius was chosen Rector of the university on six different occasions, and to him is credited the honor of having been the first teacher in Leyden to make anatomical demonstrations on the human cadaver; he also was the first to institute bedside instruction on the continent, this method being followed in Leyden as early as 1591.

A complete collection of the writings of Heurnius was published by his son, Otto van Heurne, under the title: "Opera omnia, tam ad theoriam quam ad praxin medicam spectantia, in duos tomos distributa ac edita," Lyons, 1608. A. H. B.

Hewson, William.—Born at Hexham, Northumberland, England, May 14, 1739. He derived his early medical education partly from his father, who was a surgeon, and partly from an instructor in Newcastle. Then he visited London, Edinburgh and Paris. Upon his return to London the two Hunters assigned to him the duty of supervising the dissecting work in their amphitheaters and of conducting the recitations based upon their lectures. In due course of time he gave independent courses of instruction in anatomy, and these proved to be very popular. In 1772 he was elected a member of the Royal Society. Not long afterward, while dissecting a cadaver which was far advanced in decomposition, he injured his finger with the saw used for opening the cranium, and the wound thus produced gave rise to blood poisoning, from the effects of which he died May 1, 1774.

Hewson, who was a distinguished anatomist and a scientific investigator of great promise, had already,

before his premature death, published several of his writings. Of these we can give here the titles of only two: "Experimental Inquiries into the Properties of the Blood," etc., London, 1771–1774; "On the Operation of Paracentesis Thoracis proposed for Air in the Chest; with Remarks on Emphysema and Wounds of the Lungs," in Medical Observations and Inquiries, 1767, tom. III. A. H. B.

Hexamethylenamine.—Hexamethylene-tetramine, aminoform, urotropin, cystamine, cystogen, formin, formamine, uramine, uritone, ammonioformaldehyde, etc. $(CH_2)_6N_4$, is made by combining six molecules of formaldehyde with four of ammonia. It forms rhomboidal crystals of neutral or faintly alkaline reaction, and is soluble in 1.2 parts of water, slightly in alcohol, and scarcely at all in ether. In the urine it may be detected by the formation of an orange precipitate with a few drops of a saturated solution of bromine.

Introduced in 1895 by Bordet, this remedy has come into universal use as a urinary antiseptic. It is very rapidly absorbed, Casper finding it in the urine in ten minutes; usually the urine continued to give off formaldehyde for several days. In a few cases no formaldehyde was demonstrable though the drug itself was constantly excreted, and Citron calls attention to the fact that formaldehyde is sometimes not liberated in strongly alkaline urine.

The drug has been recommended as a diuretic, a uric-acid solvent, and a urinary antiseptic and acidifier. Thompson considers its diuretic powers to be very slight, though other observers report considerable increase in the flow of urine following large doses. As a uric-acid solvent Casper found that neither a solution of the drug nor the urine of a patient taking it had any effect *in vitro*. He discovered accidentally, however, that it caused complete cessation of all visible phosphate excretion in a case of phosphaturia.

It is in bacterial conditions of the urine, however, that hexamethylenamine finds its chief indication. In typhoid fever there is much evidence that the bacilli are prevented from developing in the urine; at Johns Hopkins Hospital the typhoid bacilli did not completely disappear from the urine, but were much diminished in numbers. Osler recommended the drug very highly in typhoid cystitis. In suppurative pyelitis and cystitis it has the power of greatly lessening bacterial action, while at the same time it tends to diminish the alkalinity or increase the acidity. When the urine is strongly alkaline it sometimes fails to act. Cohn found no improvement in tuberculous cystitis or in cystitis following acute gonorrhea, but Bangs and others advise its routine employment in gonorrhea, as it tends to keep the urine antiseptic and to lessen the tendency of the gonococcus to invade the posterior urethra and bladder. A. R. Elliot of Chicago gives up to 6 gm. (ʒ iss.) a day, though noting that the acidity of the urine may be so increased thereby as to cause irritation. But there are a number of reports of vesical irritation, hematuria, and even melena following much smaller doses. W. Langdon Brown reports two cases of vesical hematuria from ten grains three times a day for eight days. Morton noted burning in the urethra and frequent micturition from twenty-four grains a day. Biss, in 311 typhoid cases, noted irritation and slight hematuria twice. The general opinion seems to be that the blood comes from the bladder and not from the kidneys, though it is advised not to employ the drug in cases of nephritis. Eastman noted lowering of temperature and pulse. The ordinary dose of hexamethylenamine is 0.2–0.5 gm. (gr. iij.–viij.), and Nicolaier advises that 1.5 gm. (gr. xxiij.) a day should not be exceeded. It is best administered with plenty of water in small doses frequently repeated.

W. A. Bastedo.
R. J. E. Scott.

Hexamitus.—A genus of flagellate protozoans. Several species are known to occur as intestinal parasites in oysters, frogs, and mice. See *Protozoa*.
A. S. P.

Hexanth-embryo.—A larval stage in the development of certain tapeworms. It has six hooks with which it bores into the tissues of some animal where it becomes encysted and awaits its final host. See *Cestoda*.
A. S. P.

Hexapoda.—*Insecta*. Arthropods with six walking legs, a characteristic which distinguishes them from the spiders which have eight. See *Insects, parasitic*, and *poisonous*.
A. S. P.

Hexone Bases.—This is the term applied to the basic bodies arginine, histidine and lysine obtained from proteins as cleavage products. They were so designated from the fact that each contains six carbon atoms. They are of considerable significance from the standpoint of intermediary metabolism. See *Arginine, Histidine, Lysine*.
F. P. U.

Hexoses.—From the fact that they contain six atoms of carbon certain of the simpler carbohydrates are called hexoses. They include the simple sugars such as dextrose, levulose, and galactose. See *Aliment*.
F. P. U.

Hey, William.—Born on September 3, 1736, near Leeds, England, of a family, through his mother's line, famous for the number of physicians it had produced. When fourteen years of age he expressed an ardent wish to enter the navy, but acceding to the desires of his parents, he became apprenticed to a Mr. Dawson, a surgeon and apothecary of Leeds. In 1757 he went to London and two years later completed his medical education. At twenty-three years of age he began the practice of surgery in Leeds and during his first year performed three lithotomies. In 1817 he assisted in the organizing and building the Leeds Infirmary, becoming one of its surgeons. In 1773 he sustained a severe injury to one of his knees, and while he recovered sufficiently to be able to practice, through a series of accidents later on, he became unable to walk more than a few steps across a room, and for more than forty years was compelled to use crutches entirely. Incapacitated by his infirmity he resigned his position as surgeon to the Leeds Infirmary in 1812. He died March 9, 1819, at Leeds.

Dr. Hey was especially noted for his surgery on hernias, although he did not confine himself to this particular subject. His name is associated with the condition called fungus hematodes, and he was the first to describe the condition known as hernia infantilis. Hey's ligament, or the falciform process of the fascia lata, was first recognized and satisfactorily described by him. He devoted very little of his time to writing and the best known articles from his pen are "Practical Observations" in three volumes, published respectively in 1803, 1810, and 1814; and an essay on "Observations on the Blood," published in 1779.
E. L. J.

Hiccough.—See *Diaphragm, Diseases and Injuries of the*.

Hickman, Henry Hill.—Born in England, January 27, 1800. He became a member of the Royal College of Surgeons when he had barely reached the age of twenty-one, and at once commenced practice in the little town of Ludlow, in Shropshire. "Impressed

by the agonizing sufferings of those on whom he was called to operate, he resolved to seek some method of alleviating their pain by rendering them unconscious before the operation.* With this object he commenced a series of experiments on animals, first, by producing semi-asphyxiation by the exclusion of atmospheric air; then by causing them to inhale small quantities of carbon dioxide, and, later, nitrous oxide gas. After rendering the animals unconscious, he excisedthe ears, amputated their legs, made incisions, then dressed the wounds, noted the time they took to heal, and the period of their complete recovery. He carried on these experiments for some time, and at last met with considerable success. This convinced him that, could he but carry out his experiments on the human subject, his methods would become of the greatest value to mankind in making painless the performance of major surgical operations.

"In 1825 Hickman removed to Shifnal, and endeavored to demonstrate the results of his experiments before his professional brethren, but everywhere he was met with the greatest scepticism, and his system was generally derided and condemned as dangerous and useless. He had one sympathizer, however—a Mr. T. A. Knight, a layman. Unable to get publicity through the medical press of the period, Hickman at length published an account of his investigations and his methods of inhalation to produce unconsciousness in the form of a letter, which he addressed to Mr. Knight.

"Disheartened by his failure to secure a hearing from the profession in his own country, Hickman at length resolved to lay the matter before the Royal Academy of Medicine in Paris, and drew up the following memorial to King Charles X., praying for permission to perform his experiments before the leading medical men of that city.

"The reading of the memorial before the Academy caused a sensation, but Hickman's discovery was received by the majority of the members with derision and contempt, the only defender of it being the famous Baron Larrey, who offered himself to be experimented upon, and, although a committee was formed to go further into the matter, the demonstration was apparently allowed to drop." Hickman, discouraged and well-nigh broken-hearted, returned to England to die a few months afterward at the early age of twenty-nine. He was buried at Bromfield, Shropshire, in the year 1829.

The article from which the text quoted above is taken ends with the following statement: "Although eighty-four years have passed away since Hickman placed his methods of producing anesthesia by inhalation before the Royal Academy of Medicine of Paris, it is not too late to do honor to the memory of this young English surgeon, now forgotten, who practically sacrificed his career and gave his life in his attempts to gain recognition for his discovery of a method of producing anesthesia by inhalation, and so rendering patients unconscious to pain during severe surgical operations." A. H. B.

Hicks, John Braxton.—Distinguished both as a teacher and as an original investigator in the domain of midwifery. Born in England in 1825 he received his professional training chiefly in Guy's Hospital, London. In 1851 he obtained his doctor's degree from London University. He held at one time or another the following different positions: Physician Accoucheur and Instructor in Midwifery and Diseases of Women and Children in Guy's Hospital; Physician of the Royal Maternity Charity; Physician of the Royal Infirmary for Women and Children; and Consulting Physician at St. Mary's Hospital. In 1866 he was elected a Fellow of the Royal College of Physicians. He died on August 28, 1897. He is credited with having introduced the method of podalic version by combined external and internal manipulation.

The following are the titles of some of the more important of Hicks' published writings: "On Combined External and Internal Version," London, 1864; "On Uterine Polypi," and "On Transfusion," in *Guy's Hospital Reports* for 1861; "On Concealed Accidental Hemorrhage," and "An Inquiry into the Best Mode of Delivering the Fetal Head after Perforation," in the *Obstetrical Transactions*, 1861, 1864; and "On Auxiliary Forces concerned in the Circulation of the Pregnant Uterus, etc.," in *Proceedings of the Royal Society*, 1879. A. H. B.

Hidrocystoma.—Definition.—A non-inflammatory affection, appearing almost exclusively upon the face, especially upon the forehead, nose, and cheeks, and characterized by the presence of discrete pin-head to pea-sized rather deeply seated translucent or boiled sago-grain like vesicles.

History.—In 1884 at a meeting of the American Dermatological Association in a paper on miliaria and sudamina I described the clinical and microscopical characters of an eruptive met with especially in middle-aged or older women, and especially in washerwomen whose faces are exposed to a warm moist atmosphere and perspire freely. The lesions were shown to be connected with the sweat apparatus, and was classed as a form of sudamina.[1] As, however, it differs clinically and histologically from sudamina proper and represents a clinical entity I suggested in a subsequent paper[2] the name hidrocystoma for the affection and this term has been employed by all subsequent writers. In 1886 Dr. G. I. Jackson[3] described an example of the affection under the term dysidrosis of the face and Hallopeau[4] a case under the title "sur un cas de dysidrose du nez." Since this time many cases have been seen and a number of articles written on the subject by different writers.

Symptoms.—The disease is not an infrequent one in New York City, especially in hot season. It occurs especially in women in middle life or older and the majority of the cases I have seen the women have been doing general housework, housewives doing cooking, washing, etc., and whilst some of them did but little if any washing of clothes the rule was that washing was credited with the cause of the eruption, the excessive perspiration in a warm moist atmosphere apparently favoring the formation of the lesions. The disease may appear however in women of leisure and is not very infrequent in the male sex, especially in corpulent individuals who perspire freely. All the cases I have seen have been worse in summer than in winter and in many the eruption would almost if not entirely disappear in cold weather. In the case reported by Hallopeau the eruption was more severe at the menstrual period and also worse in summer than in winter. The eruption may be said to be confined to the face and especially upon the lower half of the forehead, the orbital region, the nose and cheeks. It may also occur upon the lips. I have not seen it upon the lower jaw or upon the neck. The lesions are either discrete or situated closely to each other, but the latter arrangement is infrequent unless the lesions are numerous. The lesions are few or numerous in individual cases and appear as tense, clear shining vesicles, obtuse, round or ovoid in form, and varying in size from that of a pin-head to that of a pea. They are at first rather deeply seated as the base reaches deeply into the corium, but on account of their size they are also more or less elevated above the general surface. The smaller ones especially bear considerable resemblance to a boiled sago grain. The larger lesions sometimes have a darkish blue tint which is most marked

*The account here given is taken from the *British Medical Journal* of April 13, 1912.

at the periphery. There are no inflammatory symptoms present but a faint hyperemic areola is sometimes present. Individual lesions may persist for weeks or months, remaining clear, never becoming purulent, disappearing by absorption or drying up, when they may have a whitish appearance somewhat like that observed in milium. I have not been able to recognize with positiveness the presence of an excretory sweat duct ossified over the central part of an individual vesicle. There are, as a rule, no subjective symptoms but the eruption may be accompanied by a slight sensation of tension or smarting. The contents are always at first slightly acid and never alkaline and when the lesions disappear the part is left in a normal condition or there may be slight pigmentations.

Pathology.—In Fig. 3167 is shown a section containing a large and small lesion. Microscopical examination of sections showed the following condition in active stages of the disease. The corneous layer

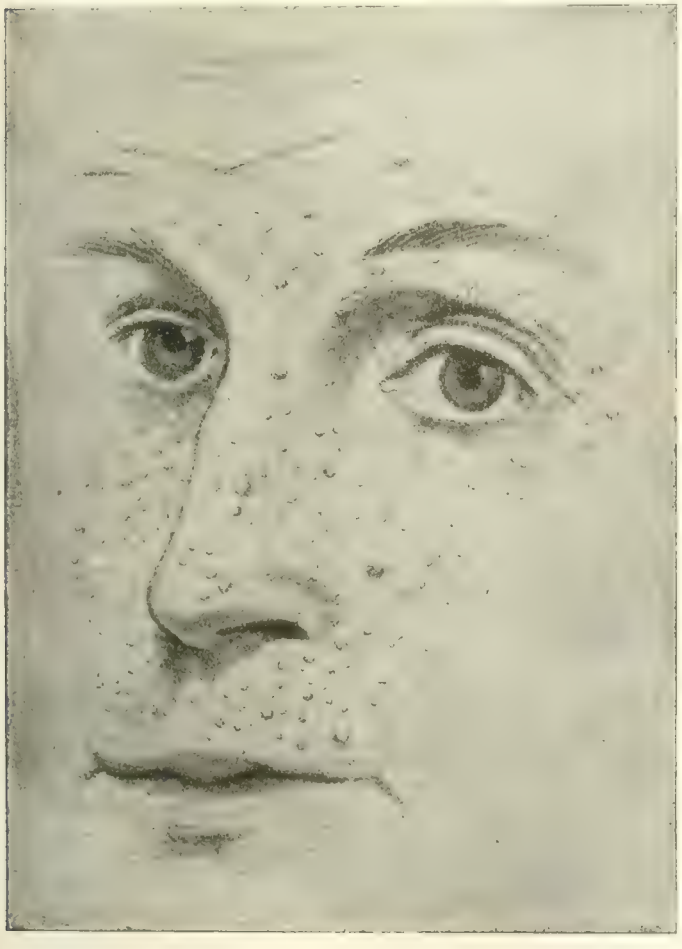

Fig. 3166.—Hidrocystoma. (Author's case.)

and the rete were in an apparently normal condition that is the corneous cells appeared to be unchanged in character and were in normal relations to each other. In the rete similar normal conditions were present, the excretory sweat ducts passing through it were normal and in no part were there any signs of vesicular formation or of any excessive transudation of serum into or between the cells. The papillary layer was normal in the early stage of lesion formation, later the circulation was more or less interfered with from pressure, with a possible slight perivascular cellular infiltration. In the upper part of the corium similar conditions existed. The sebaceous glands and hair follicles were normal. According to Schidachi[5] there is an absence of the excretory duct of the sweat gland above the cyst formation. He produced in cats a sweat gland cyst by destroying the continuity of the sweat duct, shutting off the coil part from the general surface. It is well known that sweat gland cysts are frequently caused by constriction of the excretory duct in pathological condition in the corium, but such cysts do not make a hidrocystoma.

The causation of the condition leading to the cyst formation is apparently excessive sweating in connection with a change in the skin by exposure to a warm moist atmosphere. That all the sweat glands are not effected is no proof against this view, as in ordinary sudamina the vesicles appear in connection with a limited number of excretory sweat ducts.

In the lower part of the corium and in the subcutaneous tissue, besides normal sweat glands and hair follicles, the following conditions were found. The secreting portions of some of the sweat glands have an enlarged lumen filled with liquid and a granular material resembling that in normal glands but in increased amount. As I have observed this in cases of simple hyperidrosis it may be regarded as merely showing marked activity. With the exception of those few with enlarged coil tube and those ducts connected with the cysts there was nothing abnormal observed in the sweat gland structures.

By studying Fig. 3167, it is easy to learn the anatomical relations of the lesions in this disease and see that the vesicles arise from a cystic dilatation of the excretory sweat duct lying within the corium. On the right half of the drawing is seen a small cyst connected with the sweat gland *c*, and on the left half of the drawing is a much larger cyst connected with the excretory duct seen cut transversely at *b*. At *c* is seen the coil portion of the gland. Nothing abnormal was to be observed, unless it was that the contents of the lumen were more granular than usual. The short, excretory duct leading to the cyst was perfectly normal, not showing any dilatation. The cyst *a*, was a small one, and appeared to the naked eye a pin-head sized, deep-seated vesicle. The cyst contents have disappeared but were no doubt a clear liquid of acid reaction as such was the character of all examined in reference to this point. A slight albuminous substance clung to the wall of the cyst. The excretory duct is seen very distinctly entering the cyst at the lowest right-hand corner. The entire wall of the cyst is lined with epithelium.

In the larger cyst no sweat gland is visible in this section, although its special gland was seen in other sections. At the upper part, however, at *b*, is seen the place where the excretory duct communicates with the cyst. This cyst extends further upward and further downward in the cutis than the smaller one, but it may have commenced at about the same level. The contents of this one have also disappeared. The walls are lined throughout with epithelium as in the smaller lesion.

A consideration of the conditions present shows that the cysts arise from dilatation of the excretory duct of the sweat glands at some part of its course in the corium. That it is not a passive dilatation as in an ordinary retention cyst is shown by the fact that

whether the cyst be large or small there is such a rapid proliferation of the epithelium lining the cyst that the entire cyst wall is lined with this epithelium, perhaps with more than one layer.

As regards the character of the contents of the vesicles, they are always, in the earlier periods at least, liquid and clear and slightly acid, characters similar to those present in sweat drops upon a clean cutaneous surface. This liquid is collected within an excretory duct deep in the corium and far removed from the blood-vessels of the papillæ. The connection of the cysts with the sweat coil is proven by the sections, hence we have here a positive proof that a liquid corresponding in character with sweat as it appears upon the free surface is formed by the sweat glands or excretory duct or by both. The theory,

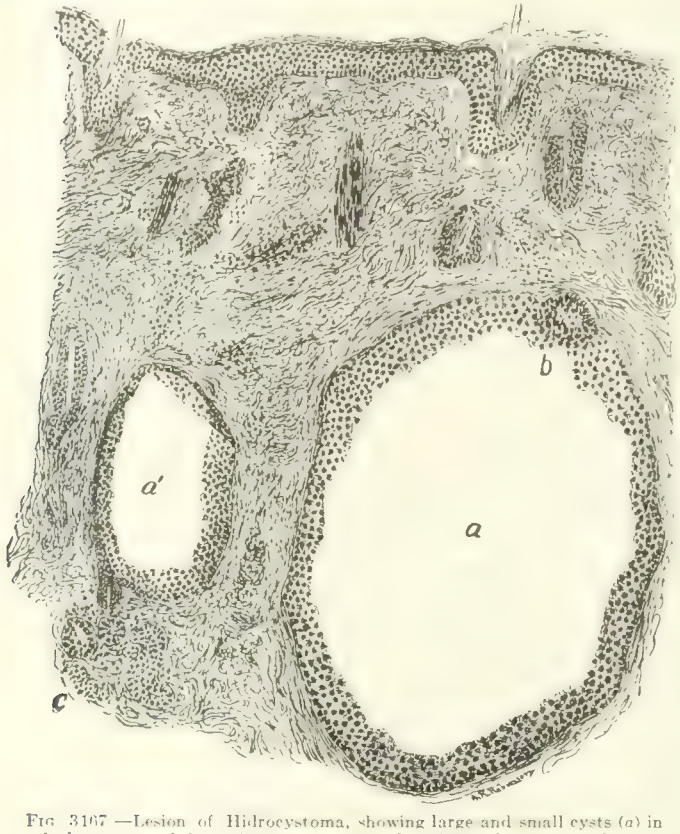

Fig. 3167.—Lesion of Hidrocystoma, showing large and small cysts (*a*) in the lower part of the corium, an excretory duct (*b*), and a sweat-coil (*c*).

therefore, that the sweat glands are fat-producing glands only and not sweat-producing, cannot be correct when we find such a condition during a state of hyperidrosis. Years ago I maintained that my sections disproved the theory that sweat comes from the papillary blood-vessels and not from the sweat glands and am still satisfied of the correctness of my position at that time.

Why the lesions form is not easily answered. One could say that the duct becomes obstructed by detached epithelium, the result of the excessive hyperidrosis, but the obstruction in that case would probably occur where the lumen is narrowest and elasticity of surrounding tissue least, that is, in the epidermis. Furthermore, the disease is rare, whilst hyperidrosis, at some time or other, is almost universal. It cannot be from any anatomical changes in the epidermis or the lesions would be more superficially seated. It cannot be from the difference in density between the connective tissue of the corium and that of the subcutaneous tissue that causes the lesions to form about the place of union of those parts, for the cyst enlarges subsequently in all directions. The nature of the contents of the vesicles show that the coil part of the glands is normal or acid sweat could not form so rapidly. The abnormal condition must reside primarily in the excretory tube or in the surrounding connective tissue, causing obstruction to the outflow of the sweat.

Diagnosis.—The eruption bears some resemblance to sudamina crystallina, pompholyx (dysidrosis), eczema, and adenoma of the sweat glands.

Sudamina are caused by retention of sweat within the corneous layer, the cells forming the wall of the duct becoming separated and allowing the sweat to infiltrate the corneous layer and pushing aside the cells, collect so as to form a dewdrop-like lesion. Clinically, the lesions of sudamina crystallina appear but very rarely upon the face, they are more superficially seated and have a thinner covering. The nature of the contents is similar in both cases and both are caused by retention of sweat within an excretory duct area, and hence, in my first paper, I preferred to describe it as a form of sudamina, giving this term a wider meaning than it previously had, making it synonymous with any lesions caused by retained sweat, and then using qualifying words as crystallina, miliaria, etc., for different clinical forms. As, however, sudamina are not lesions caused by sweat retained within an excretory duct, and as, furthermore, in the disease I have described, there is a rapid proliferation of epithelial cells in sufficient numbers always to line the cyst wall, as finally the disease has definite clinical character and represents a clinical entity, it appears to me to be advisable not to use the term sudamina of the forehead, as I have already done, but to coin a new one for the affection, namely hidrocystoma.

From eczema the eruption is diagnosed by the acid reaction of the contents, and by the absence of inflammation and subsequent crusting. The nature of the contents and the clinical history make the diagnosis from adenoma of the sweat glands easy, but in a photographic representation there is much resemblance.

Drs. Jackson, Jamieson, Rosenthal, and Hallopeau have all described the disease under the name of dysidrosis. It, however, corresponds in no respect with dysidrosis as described by Tilbury Fox, Hutchinson, myself and others, except that in both the vesicles may have the boiled-sago-grain appearance. The disease dysidrosis or pompholyx may be defined as an acute inflammatory affection, characterized by the symmetrical development upon the palms of the hands. and generally also upon the soles of the feet, of deep-seated, clear vesicles, usually grouped, which afterward become opaque, and in a few days disappear by rupture or absorption, leaving a non-eczematous skin behind. As the disease I have described in this article bears no relation from either a clinical or an anatomical standpoint with dysidrosis, the term should not be used for the affection, even if it were clear that the condition did represent one of difficult sweating, for it is clearly not the same disease already described under that name.

Treatment.—The disease does not cause any permanent injury to the part such as atrophy or pigmentation and beyond the fact that it does mar the countenance in some cases for the time being it need cause no worry. The use of a soap to thin the corneous layer

and the puncturing of the cysts, together with the use of local astringents if there are any that tend to inhibit sweat secretion covers the indications. Avoidance of the predisposing or direct causes, as the case may be, such as washing in a moist warm atmosphere, exercise causing excessive sweating, etc., should be recommended. A. R. Robinson.

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2. Robinson: Journal of Cutaneous Diseases, 1893, p. 203 (with colored plates and histological descriptions).
3. Jackson, G. T.: Journal of Cutaneous and Venereal Diseases, 1886.
4. Hallopeau: Annales de Dermatologie et de Syphiligraphie, 1886.
5. Schidachi: Experimentelle Erzeugung von Hidrocystom. Archiv für Derm. u. Syph., 1907, lxxxiii.

Highland Springs.—Androscoggin County, Maine.

Post-office.—Lewiston. Cottages.

Highland Spring is located at Thorne Hill, comprising over sixty acres of elevated and wooded land, about three miles from Lewiston station. The spot offers exceptional advantages to persons wishing to camp during the summer and is accessible by electric car line. The waters of this spring have enjoyed a considerable reputation for a long time past. They are bottled and sold extensively for table purposes. The following analysis was made by Richard C. Stanley, Ph. D., State assayer of Maine:

One United States Gallon Contains:

Solids.	Grains.
Iron carbonate	1.10
Iron oxide	0.31
Potassium and sodium carbonate	0.83
Magnesium carbonate	1.23
Potassium and sodium sulphate	0.31
Sodium chloride	1.00
Total	4.78

This is an excellent, palatable water and possesses the properties of a mild ferruginous tonic.

Emma E. Walker.

Highmore, Nathaniel.—Born in Hampshire, England, in 1613. He practised his profession in Dorsetshire. He died in 1684.

Although Highmore was not an anatomist of great merit, the fact that his name is connected with certain parts of the human body—parts to which he devoted considerable attention—has given him not a little celebrity. The terms here referred to are "Highmore's antrum" and "Highmore's body." The following is the title of the most important one of his published writings: "Corporis humani disquisitio anatomica, in qua sanguinis circulationem in quavis corporis particula, plurimis typis novis, ac ænigmatum medicorum succincta dilucidatione ornatum prosecutus est," The Hague, 1651. A. H. B.

Hill Diarrhea.—A gastrointestinal catarrh characterized by the passage of several pale frothy liquid stools every morning. It occurs mostly in European residents of the lowlands in India when they visit the hills.

The disease was at one time believed to be a form of sprue. It was first differentiated by Crombie in 1892, who stated that it was likely to appear in persons acclimated to the lowlands when they visited altitudes of 6000 feet or more. The disease sometimes appears at lower altitudes than this. It is likely to be more prevalent and to assume the appearance of an epidemic during the rainy season, subsiding as the rains cease.

It has been attributed to the change in atmospheric pressure; to change in temperature (chilling) causing a suspension of the normal hepatic, pancreatic and intestinal functions; to humidity; to the presence of mica particles in the water used for drinking and cooking; to intestinal infection with yeasts, moulds, bacteria, or animal parasites. Nothing has been definitely established as to its cause.

In fatal cases the mucosa of the stomach and intestines is found to be covered with a thick layer of mucus, but there is no ulceration. The mucosa and submucosa may show proliferative change in chronic cases.

Symptoms.—The attack is apt to come on soon after the patient's arrival in the hill country, beginning with a sudden call to stool in the early morning. This is followed during the forenoon by several loose stools, thin, yeasty, and very light in color, looking like "stirred whitewash." The movements are usually inoffensive, painless, and followed by a sense of relief. As the disease progresses they become more numerous, sometimes offensive, and in some cases painful; there is a marked flatulent dyspepsia, and the patient exhibits increasing weakness with nervous irritability. The history of the case and the absence of mouth signs distinguish the disease from sprue. If the patient leaves the hills and returns to the plain the symptoms usually subside. Persons who have suffered from this complaint should especially avoid the hill country during the rainy season.

Treatment.—The disease usually responds promptly to treatment on a milk diet with liquor hydrarg. perchlor. ℥ss to ℥i fifteen minutes after feeding, followed by a dose of pepsin, ingluvin, or lactopeptine from one to two hours afterward.

J. F. Leys.

Hilton, John.—A British surgeon who flourished during the nineteenth century and who was justly celebrated for his accurate knowledge of human anatomy. He was born at Castle Hedingham, in Essex, in 1804. He received his medical training at Guy's Hospital, London, and afterward served this institution in the following capacities: Demonstrator of Anatomy (1828), Assistant Surgeon (1845), and Surgeon (1849). He was also Surgeon Extraordinary to Queen Victoria. Hilton is credited with being the first to reduce an obturator hernia by abdominal section, and one of the first to practise lumbar colostomy. He died on September 14, 1878.

His published lectures on "Rest and Pain" constitute one of the gems of medical literature.

A. H. B.

Himantarium.—A genus of myriapods. *H. gervaisi* has been reported from the alimentary tract of man. See *Insects, parasitic.* A. S. P.

Hip-joint.—Articulatio coxæ, BNA.; articulation coxofémorale, Fr.; Hüftgelenk, Ger. A diarthrodial enarthrosis, or freely movable ball-and-socket joint, between the acetabulum, a cup-shaped cavity of the coxal bone, and the globular head of the femur. Having to support, in an erect position, the weight of the trunk, it is one of the most stable and solid joints in the body; but is also capable of a great variety of movements.

Articular Surfaces.—These are very nearly geometrically accurate, a hollow hemisphere in the hip bone receiving the approximately hemispherical head of the femur.

Acetabulum.—The cavity of reception, slightly more than twenty-five millimeters in diameter comprises from 170° to 180° of a concave sphere, and is slightly irregular on its edge, showing traces of its formation from the three primitive elements of the hip bone. At each point where these have coössified a notch may usually be seen. That between the ischium and the pubis is the largest, and is known as the acetabular notch (incisura acetabuli, BNA). The cavity as a whole looks anteriorly, laterally, and slightly downward. It is somewhat shallower at birth, and deepens as the child learns to walk. The concave interior is divided into the lunate surface, a smooth articular portion, crescentic in form, covered with hyaline cartilage; and the fossa acetabuli, a rough, non-articular portion, irregularly quadrilateral in form, cushioned over when fresh with a pad of vascular fat and connective tissue (Haversian gland), but slightly adherent to the subjacent bone and affording attachment to an extension of the round ligament of the joint.

In a fresh state the cavity is deepened by the attachment to its edge of a rim of fibrocartilage, the glenoidal labrum. Like the similar structure in the shoulder-joint, it is prismatic in section. It is thicker above and behind where the greatest stress comes, and grasps the head of the femur, narrowing the orifice and deepening the cavity which then represents somewhat more than two-thirds of a sphere. It fills in the minor irregularities of the edge, but bridges over the acetabular notch, being there known as the transverse ligament of the acetabulum. It is clothed with synovial membrane on its two free surfaces and by its elasticity adapts itself to varying movements of the two bones.

Head of the Femur.—This smooth, globular body comprises from two-thirds to three-fifths of a sphere having a radius of about twenty-five millimeters in the male and twenty in the female. Directed upward, inward, and a little forward, it is supported by the neck, a narrower portion shaped like a truncated cone, flattened from before backward. The articular surface of the head is covered with cartilage, except at a small, oval depression (fovea capitis) situated about two-thirds of the way down and nearer the posterior than the anterior border, which affords attachment to the round ligament of the joint. At the bottom of this depression small openings for vessels may usually be seen. The cartilage is thickest above, where the pressure is greater and thins away toward the periphery. At the neck it is limited by an irregularly curved line, and extends farther from front to back than from side to side corresponding to the greatest excursion of the articular surface.

Capsule.—This has the form of a sleeve larger above than below, the reverse of the condition seen in the shoulder-joint, and the contraction of the lower end, due to the diminished caliber of the neck, assists to keep the head of the femur in place and lends stability to the joint. It is inserted upon the hip bone just beyond the base of the labrum and upon the transverse ligament, thus permitting small vessels to penetrate under that structure without piercing the capsule.

Upon the femur it passes considerably beyond the articular surface, taking in a portion of the neck. In front it reaches to the intertrochanteric line, while behind, because of the numerous muscles coming to be inserted into the trochanter, it does not reach the intertrochanteric crest, but covers only about the inner two-thirds of the neck. It follows from this that all fractures of the neck are intracapsular in front, that they are intracapsular in front and behind when situated at the internal half, but when at the external half they may be intracapsular in front and extracapsular behind. Tillaux[4] notes that the synovial membrane is reflected within the capsule somewhat in advance of the fibers of the capsule, and shows that a fracture might be intracapsular and still not involve the synovial membrane. He therefore proposes that the fractures of the neck be divided into intra- and extraarticular.

The capsule is thick and very strong in front and above, much thinner and weaker below and behind. It is thinnest between the acetabular notch and the obturator foramen where the tendon of the iliopsoas muscle passes over it and behind opposite the greater sciatic notch. These weak spots usually determine the direction of dislocations. They are considerably strengthened by the tendons of muscles, the iliopsoas in front and the piriformis behind.

The fibers of the capsule are both longitudinal and circular, the latter being the deeper and more apparent behind and at the lower part. About half way down the neck such fibers are collected into a strengthening collar known as the *zona orbicularis*, which may be strong enough to make a slight impression upon the bone.

In those situations where special stress occurs, longitudinal bundles of considerable strength have been formed upon the surface of the capsule in four tolerably distinct bands. Two of these are caused by the necessity of supporting the trunk in the erect position. They pass from the anterior inferior spine of the ilium downward, diverging from each other like the branches of an inverted Y (λ), one going to the base of the trochanter major, the other to just above the trochanter minor. They have usually been described collectively as the iliofemoral ligament, ligament of Bertin, or Y ligament of Bigelow. Welcker[11] has, however, suggested that, as the two bands are distinct and perform different physiological functions, they should receive separate names, and proposes to call them the superior and anterior iliofemoral ligaments. They are both exceedingly strong. It is because of this that, in the barbarous punishment of "drawing" a criminal, by means of four horses attached to his limbs and proceeding in opposite directions, the separation at the hip-joint had usually to be completed with a knife, the ligaments resisting after several hours of trial—as was the case at the execution of Ravaillac, the assassin of Henry IV., and of Damiens, who attempted the life of Louis XV.

The superior ligament is perhaps the strongest ligament in the body, being from one-fourth to one-half an inch thick (seven to fourteen millimeters, Welcker), and stronger than the tendo Achillis. Its action is to limit the extension of the femur upon the pelvis. In the erect position the weight of the body falls behind the hip, and the pelvis is accordingly tilted backward, putting this band on the stretch, and it then sustains the whole weight of the trunk, head, and arms, a great economy of muscular force being thus effected. It also limits outward rotation and adduction.

The anterior ligament is also very strong, being nearly one-fourth of an inch thick (four to five millimeters), and the longest strengthening band of the capsule. It assists the superior ligament in limiting extension, but not in the same plane, the plane of limitation for the superior ligament being nearly parallel to the axis of the femoral neck, that of the anterior with the axis of the shaft.

The two ligaments are but slightly developed before the erect position is attained. Indications of them are found early, but they increase with the growth. In animals that can stand partially erect, such as apes and some marsupials (kangaroo), the ligaments are strong; in others slight.[13]

They have an important influence in determining the deformity which results from dislocations of the femur, and may be used as a fulcrum in reducing them.[14] Thus, it is the superior ligament which holds the neck fixed, and hence causes the inward turning of the toes in dislocation backward. In thyroid dislocation the anterior ligament causes in a similar way an eversion of the toes.

Another strengthening band of the capsule is the

pubocapsular ligament, which stretches from the obturator crest of the pubic bone to the capsule near the lesser trochanter. It is from two to three millimeters thick, and limits abduction. An ischiocapsular band is of about the same size, and stretches in a similar way from the ischial border of the acetabulum to near the digital fossa of the great trochanter, along the line of the tendon of the obturator internus, with which it is somewhat blended. It limits rotation inward. It is sometimes described as ending upon the capsule, but Welcker and others find the arrangement described the usual one.

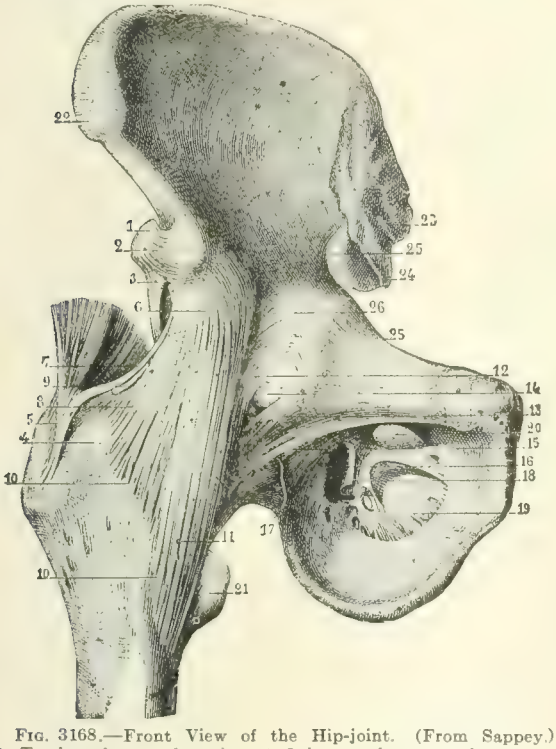

Fig. 3168.—Front View of the Hip-joint. (From Sappey.) 1, Tendon of rectus femoris, cut; 2, its attachment to the anteroinferior iliac spine; 3, reflected portion of the tendon; 4, tubercle of the trochanter major; 5, tendon of the gluteus minimus; 6, the attachment of the iliofemoral ligaments to the anteroinferior iliac spine; 7, fibrous union of the capsule with the tendon of the gluteus minimus; 8, superior iliofemoral ligament; 9, section of a very thin fibrous lamella which covers over and crosses the ligament obliquely; 10, 10, thinner portion of the capsule between the two iliofemoral bands; 11, anterior iliofemoral ligament; 12, 13, thin portion of the capsule arising from the iliopectineal eminence, and from the horizontal ramus; 14, orifice in the capsule communicating with the bursa beneath the tendon of the iliopsoas; 15, pubocapsular ligament; 16, 17, 18, 19, fibrous bands relating to the obturator membrane; 20, the obturator groove; 21, lesser trochanter; 22, anterosuperior iliac spine; 23, posterosuperior iliac spine; 24, posteroinferior iliac spine; 25, iliopectineal line; 26, iliopectineal eminence.

The action of these four bands is such that in passing from the flexed to the extended position they wind around the neck in such a way as to shorten the capsule, which, being closely united with the zona orbicularis, is drawn up against the edge of the acetabular cavity and surrounds the lower part of the head as with a ring. It may be said that the contraction is such that dislocation is impossible in the extended position.

The brothers Weber made the discovery that the head of the femur is held in position by atmospheric pressure, the amount of weight thus lifted being somewhat greater than that of the limb. This greatly economizes the muscular force required for walking. The closely fitting labium glenoidale assists this greatly, and dislocation is very unusual, if not entirely impossible, without injury to it. Men and animals that ascend mountains to a height where the air becomes sufficiently rarefied to be of less effect in upholding the weight of the limbs suffer from weakness in the joints. Hyrtl[9] states also that mountaineers, who have trained their muscles by long use in a rarefied atmosphere, are somewhat inexpert in the use of their legs when they descend to the valleys.

Synovial Membrane.—With the exception of that in the knee-joint, this is the most extensive synovial surface in the body, being estimated to occupy at least twenty square inches. It clothes not only the interior part of the fibrous capsule, but also the inclosed part of the neck and the head as far as the articular cartilage, the free surfaces of the labrum, the round ligament, and the acetabular fossa.

From the place where the membrane is reflected from the capsule on to the neck some scattered bundles of fibers, usually carrying vessels, pass in a recurrent manner upward along the neck toward the articular surface. These raise the synovial membrane into falciform folds called *retinacula*, which are more commonly seen in the young, before the epiphysis for the head, which lies entirely within the capsule, coossifies. In the adult they are not always present nor is their situation constant. Synovial fringes are often found here and also about the round ligament, but never as well developed as in the knee-joint.

Ligamentum Teres.—An apparatus connected with the synovial membrane of the joint is the so-called ligamentum teres, or round ligament (ligamentum intraarticulare coxæ, Fick)—which is not round, nor, properly speaking, a ligament, being a flattened band quite similar to the synovial processes with which it is united at both ends (see Fig. 3169). It passes from the fossa at the bottom of the acetabulum, being attached by two bands, one on each side of the acetabular notch, blending with the transverse ligament, to the fovea upon the head of the femur. Unlike interosseous ligaments, it does not extend in the shortest direction from one bone to the other, but is in a manner rolled around the lower part of the head (Fig. 3170). It is composed of loose connective tissue and contains vessels.

Various surmises have been made as to its use. It was formerly held to be for the purpose of limiting outward rotation and adduction during flexion[5, 6, 7]. It has been shown, however, that if the capsule is left intact, these motions are more closely limited than when it is severed and the strain comes alone upon the ligamentum teres. Tillaux[4] thinks that it tends to break shocks delivered by the femur upon the top of the acetabular cavity in jumping, etc. Sappey[3] supposes that its principal function is the protection and conveyance of vessels to nourish the head of the femur; but Hyrtl[9] finds that, upon careful injection of the arteries, only the round ligament and the fatty cushion at the bottom of the acetabulum become reddened, and that at the insertion of the round ligament upon the femoral head the capillary arteries loop back and unite with veins. An injection of the superior nutrient artery, on the contrary, fills the capillaries of the cancellous tissue of the head. This explains the well-known pathological fact that an intracapsular fracture of the femoral neck is likely to be followed by non-union of the fragments, notwithstanding that the ligamentum teres may be left intact. Langer,[10] however, finds that, in young subjects, vessels of considerable size pass through directly into the proximal epiphysis of the femur, and suggests that its function is connected with the nourishment of that epiphysis. When this becomes united, its vascular system is connected with that of the nutrient artery, and the branches received through the ligament gradually atrophy, until in old age they are almost entirely wanting.

Welcker[11] has made a careful examination of this ligament in the animal series, as well as in human embryos, and considers it a process of synovial membrane originating as a fold at the side of the articular surface, and gradually detached by the twisting of the limbs. In some animals quite near man, as the orang (occasionally also in man), it is wanting, but it may be said to be generally present when there is much differentiation of the hind limbs. In the tapir it is reduced to a process attached only at the side, a condition occasionally found in a synovial fold of the human shoulder-joint.

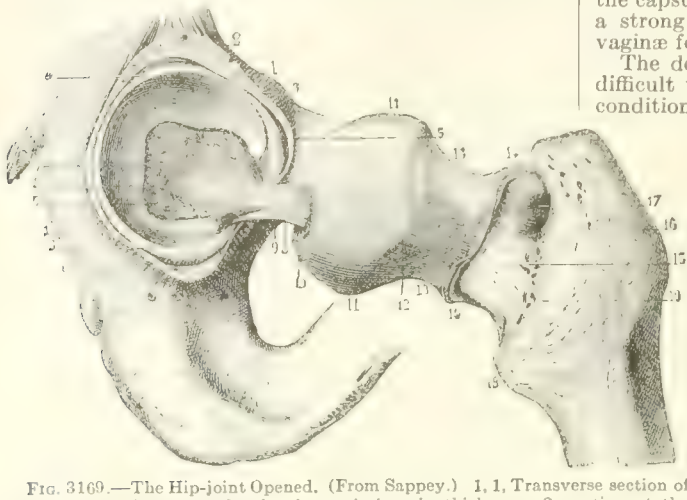

Fig. 3169.—The Hip-joint Opened. (From Sappey.) 1, 1, Transverse section of the capsular ligament, showing its variations in thickness; 2, section at the situation where it is strengthened by the iliofemoral bands; 3, 3, free edge of the labrum glenoidale; 4, 5, 6, semilunar interspaces which separate that ligament from the capsule; 7, 7, pad of fat at the bottom of the acetabulum; 8, 9, the ligamentum teres; 10, the fovea, or depression on the head of the femur; 11, 11, head of the femur; 12, farthest extent of the articular surface behind; 13, 13, that posterior portion of the neck that is invested with synovial membrane; 14, 14, oblique line where the synovial membrane is reflected; 15, that posterior portion of the neck that remains without the capsule; 16, great trochanter; 17 trochanteric fossa; 18, lesser trochanter; 19, intertrochanteric crest.

On of the most interesting views as to the nature of this puzzling structure is that of Sutton,[12] who thinks it a vestige of a tendon, probably a former attachment of the pectineus. The ambiens muscle of ostriches, homologous with the pectineus, carries its tendon into the joint to the head of the femur. In the lizard *Sphenodon*, the pectineus has two heads, one going to the femur, the other to the pubic bone, reminding one of the biceps brachialis. In the horse the ligamentum teres has two parts, one of which is continuous with the pectineus.

Relations.—The liability of the articulation to disease and injury is considerable, on account both of its size and of the pressure upon the surfaces. It is therefore important to determine its precise position and relations—and this is by no means easy, as it lies buried under thick masses of muscle. In front is the reflected tendon of the iliopsoas, a bursa (*B. iliaca*) intervening, which sometimes communicates with the joint cavity. Above, the reflected tendon of the rectus femoris and the gluteus minimus are firmly united with the capsule (see Fig. 3168). Medially lies the pectineus above, also united with the capsule, and the obturator externus below. The tendon of this latter muscle also lies posteriorly, together with the obturator internus, the gemelli, the piriformis, and the quadratus femoris.

All these form an immediate investment for the joint, and are themselves partially covered by a second mass composed of the tensor vaginæ femoris, the gluteus maximus and medius behind and externally, the biceps group behind, and the adductor group internally.

Over these muscles there stretches the fascia belonging to the different groups, and in several situations this notably strengthens the joint capsule, especially where the iliac fascia comes down from the iliopsoas, where the pectineal fascia passes outward upon the capsule from the pectineus, and, externally, where a strong process passes inward between the tensor vaginæ femoris and the rectus femoris.

The depth at which the articulation lies makes it difficult to obtain any positive knowledge as to the condition of the joint by direct manipulation, but a fairly accurate notion of its situation may be had by noting the surface forms and bony points of the region. As to the bones, note first the anterior superior iliac spine, always marked even in the fattest subjects; then the pubic tubercle, which can easily be found by abducting the thigh and then running the finger along the strong tendon of the adductor longus which starts up. Joining these two points is the inguinal ligament, which may easily be felt. The muscular prominence on the outer side of the leg is caused by the tensor fasciæ latæ, on the inner by the adductor muscles, and the triangular interval between, which reminds one distantly of the axillary space, is the trigonum femorale, or Scarpa's triangle. It is through the middle of this that the great vessels pass down the thigh, and the beating of the femoral artery, which lies nearest the joint, may be felt by pressing just below the inguinal ligament. The joint is about half an inch external to this, and in a very lean person (easier in cadaver) the head of the femur may be felt rolling under the fingers by pressing deeply here while an assistant extends and rotates the limb. This is impossible, however, when the subject is even moderately fat. A fulness and tenderness here are noted in the early stages of hip disease, when there is effusion into the joint. Pus forming around the joint is always confined, and burrows extensively along the lines of fascia above mentioned. An abscess pointing below the inguinal ligament, and external to the vessels, usually comes from the joint.

Two other bony points should be noted. First, the ischial tuberosity, which is the part upon which

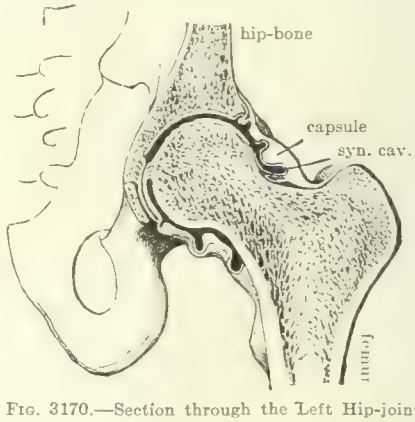

Fig. 3170.—Section through the Left Hip-joint.

the weight of the body rests in sitting. In the erect posture it is concealed by the gluteal fold behind, but may readily be made out by palpation. Second, the great trochanter, which is situated on the outer part of the upper thigh, about four inches below and behind the anterior superior iliac spine. The top of it is on a level with the pubic tubercle, and about

three-fourths of an inch below the head of the femur. When the leg is abducted the trochanter will be found at the bottom of a depression; when adducted and rotated inward it makes a prominence. The anterior superior iliac spine, the ischial tuberosity and the pubic tubercle are all about equally distant from the bottom of the acetabulum. A line connecting the first two is known as Nélaton's line. It grazes the great trochanter and passes directly over the middle of the acetabulum when the thigh is slightly flexed. By noting the extent of displacement of the trochanter with reference to this line, much can be made out as to dislocation or fracture. Upon rotating the femur the trochanter will be seen to describe the arc of a circle having a radius equal to the length of the head and neck; in case of fracture the arc is much less, the bone rotating merely upon the axis of the shaft. The patient being in the recumbent position, a fracture of the neck may also be detected by noting the displacement of the trochanter toward a line dropped vertically from the anterior superior iliac spine (Bryant).

Of the articular surfaces the acetabulum is the more liable to disease, because it is composed of a greater variety of elements. The three primitive bones, the ilium, ischium, and pubis, which unite to make the hip bone, all participate in the formation of the cavity. Up to the age of puberty the component bones are separated by a Y-shaped strip of cartilage. It is probably on account of the unusual activity required by the osteogenic process here that the joint is so prone to disease in childhood, hip disease rarely occurring after ossification is completed.

The lower part, both because of its vascularity and on account of its want of protection by cartilage, is usually the first attacked by inflammatory processes. It is also in this situation that the walls are thinnest, as it is necessary to buttress above against the thrust of the femur in the erect position. The thinness here explains the ease with which inflammatory processes may be propagated, an arthritis giving rise to a pelvic cellulitis, and a pelvic abscess occasioning inflammation of the joint. Perforation of the acetabulum is not very common, as the pressure is but slight.

Within the pelvic cavity the situation corresponding to the acetabulum is covered in part by the obturator internus. When perforation occurs it must therefore be in one of three positions—either upon the muscle, behind it, or in front of it. In the first instance the pus passes out with the tendon of the muscle at the lesser sciatic notch, and points upon the nates. When the perforation occurs behind, the pus goes into the ischiorectal fossa, and discharges through the perineum or into the rectum. When it occurs in front, the pus passes upward along the sheath of the obturator vessels and makes its appearance in the groin.[3]

Arteries.—The arterial supply of the joint is from the deep femoral by ascending branches from the medial and lateral circumflex, and from the hypogastric artery by the obturator, superior and inferior gluteal. The capsular ligament is remarkable for the number of vessels and nerves that ramify in it.

Nerves.—The joint is supplied with nerves from the lumbar plexus through the femoral nerve by branches given off immediately after that trunk leaves the pelvis, and through the posterior branch of the obturator nerve. Also from the sacral plexus by small branches either direct from the nerve to the quadratus femoris or from the upper part of the sciatic nerve.

Movements.—All possible movements are allowed, but are much more limited in range than at the shoulder-joint.

Flexion and Extension.—These occur about an axis that extends along the central line of the neck from the top of the great trochanter to the acetabular fossa. The arc of excursion is about 130°. Flexion, the most extensive movement, is produced by the iliopsoas, rectus femoris, sartorius, pectineus, obturator externus, adductor longus and brevis, pubic part of adductor magnus and the anterior fibers of the gluteus medius and minimus. It is checked by contact of the thigh with the abdomen and by the lower fibers of the ischiocapsular ligament. If the knee be extended the hamstring muscles check flexion beyond 90° in most persons, as can easily be demonstrated by attempting to touch the floor with the fingers without bending the knees.

Extension is produced by the gluteus maximus, biceps, semitendinosus, semimembranosus, the ischial part, of the adductor magnus, and by gravity. It is checked by the iliofemoral ligament.

Adduction and Abduction.—These occur about an anteroposterior axis passing through the center of the head. The excursion is about 85° to 90°. Adduction is produced by the adductors, pectineus, gracilis, quadratus femoris, lower part of gluteus maximus, and is checked by contact with the other limb, or by the lateral part of the iliofemoral ligament.

Abduction is produced by the gluteus minimus, medius, upper part of maximus, tensor fasciæ latæ, sartorius and obturator externus, and, when the limb is flexed, by the piriformis, obturator internus and gemelli, and is checked by the pubocapsular and medial part of the iliofemoral ligaments.

Circumduction.—This is produced by combining the above movements.

Lateral Rotation.—Produced by the gluteus maximus, posterior fibers of the gluteus medius and minimus, the adductors, both obturators and the gemelli, piriformis, quadratus femoris, sartorius, pectineus, and, when the thigh is flexed, by the iliopsoas. It is much stronger than medial rotation and is checked by the iliofemoral ligament and slightly by the ligamentum teres.

Medial Rotation.—Produced by iliopsoas when thigh is not flexed, by anterior fibers of gluteus medius and minimus and by the tensor fasciæ latæ. It is checked by the ischiocapsular ligament. Frank Baker.

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Hip-joint, Congenital Dislocation of.—See *Dislocations, Congenital.*

Hippobosca.—A genus of flies that is parasitic on cattle, horses, dogs, etc., all over the world. Some are believed to transmit diseases. See *Insects, parasitic.* A. S. P.

Hippocrates.—Born in 460 B.C., on the island of Cos, near the coast of Asia Minor. He was a member of the family of the Asclepiadæ, and was believed to be either the nineteenth or seventeenth in direct descent from Æsculapius. He studied medicine under Heraclides, his father, and Herodicus of Selymbria. He traveled extensively, and taught and practised his profession at Athens, probably also in Thrace, Thessaly, Delos, and his native island. He died at Larissa in Thessaly at an advanced age.

The writings of Hippocrates which have come down to us are in such a chaotic state that it is a very difficult matter to make up one's mind, in reading any particular portion of the text, as to what may justly be attributed to Hippocrates himself and what should be considered as the work of another. It is an error—as the writer of the article on Hippocrates in the "Dictionnaire Historique de la Médecine" states—to assume that the history of medicine begins with Hippocrates; his writings, it is perfectly evident, represent the accumulated experience of the physicians belonging to many centuries preceding that in which Hippocrates lived. To quote the latter's own words: "Medicine has discovered certain fixed principles and the road along which, for many centuries past, sure progress has been made in accumulating an infinite number of precious truths. He who, possessing a fair measure of talent, directs his researches from these known truths as a starting point, is reasonably sure of adding to their number; while he who, casting them to one side, pursues another route and then pretends that he has discovered certain fundamental dogmas, deceives both himself and others." Some idea of the value of the truths which had been gathered together by physicians up to the time when Hippocrates lived may be inferred from the simple statement that the therapeutic agents then employed are among those which even to-day rank among the most powerful remedies that we possess—such, for example, as blood-letting, the employment of purgatives, emetics and narcotics, and the more important modifications of the dietetic régime.

Fig. 3171.—Hippocrates.

The lack of space will not permit us to enter into further details relating to the precise degree of knowledge possessed by Hippocrates in the departments of anatomy, physiology, pathology and therapeutics; but we cannot refrain from introducing here another quotation, this time from Sir John B. Tuke (in *Cyclop. Brit.*, 11th edition): "One of his great merits is that he was the first to dissociate medicine from priestcraft, and to direct exclusive attention to the natural history of disease. How strongly his mind revolted against the use of charms, amulets, incantations, and such devices appears from his writings; and he has expressly recorded, as underlying all his practice, the conviction that, however diseases may be regarded from the religious point of view, they must all be scientifically treated as subject to natural laws. . . . . Laënnec, to whom we are indebted for the practice of auscultation, freely admits that the idea was suggested to him by the study of Hippocrates, who, treating of the presence of morbid fluids in the thorax, gives very particular directions, by means of succussion, for arriving at an opinion regarding their nature.

The best edition, for English readers, is the translation by Adams, entitled the "Genuine Works of Hippocrates," published in England by the Sydenham Society and in America by William Wood & Company.

A. H. B.

Hippocratic Oath.—The ancient Greek writings commonly called "The Works of Hippocrates of Cos" were judged even by the Greek critics to be really by various authors. The truth of this conclusion is plain to modern scholars. These writings have probably existed as in some sort a collection since the early days of the Alexandrine library near the beginning of the third century B.C.; and the composition of the several writings may safely be referred to the fifth or fourth century. Which of them are truly works of the famous physician whose name they bear is quite uncertain, as no direct contemporary testimony exists. Modern critics can only sift internal evidence, and compare the views of earlier critics, ancient, perhaps, but often naïve or biassed. Many writings in the collection, however, are plainly as old as Hippocrates, if not older. He was born in 460 B.C., died probably in 377 B.C., and was a worthy of the great period often styled that of Pericles. There is no proof, however, that Hippocrates was ever at Athens, though he was known there; and scarcely anything is known of his life with certainty.

One of the most famous writings of the Hippocratic collection is that entitled "The Oath." It is probably at least as ancient as Hippocrates, but that he composed it can neither be affirmed nor denied. Traces of its widespread influence occur in history; and by means of it modern physicians still hand down the traditions of their calling to those about to receive a medical degree. The ancient words do not accord with the changes wrought by twenty-two centuries in men, beliefs, and manners; but no modern words can be nobler, and the ancient thoughts are vital to the modern oath. The following translation of the Greek original into English is by the present writer:

The Oath.

"I swear by Apollo the Physician, and Æsculapius, and Hygeia, and Panacea, and all the gods and all the goddesses—and I make them my judges—that this mine oath and this my written engagement I will fulfil so far as power and discernment shall be mine.

"Him who taught me this art I will esteem even as I do my parents; he shall partake of my livelihood, and, if in want, shall share my goods. I will regard his issue as my brothers, and will teach them this art without fee or written engagement if they shall wish to learn it.

"I will give instruction by precept, by discourse, and in all other ways, to my own sons, to those of him who taught me, to disciples bound by written engagement and sworn according to medical law, and to no other person.

"So far as power and discernment shall be mine, I will carry out regimen for the benefit of the sick, and will keep them from harm and wrong. To none will I give a deadly drug, even if solicited, nor offer counsel to such an end; likewise to no woman will I give a destructive suppository; but guiltless and hallowed will I keep my life and mine art. I will cut no one whatever for the stone, but will give way to those who work at this practice.

"Into whatsoever houses I shall enter I will go for the benefit of the sick, holding aloof from all voluntary wrong and corruption, including venereal acts upon the bodies of females and males whether free or slaves. Whatsoever in my practice or not in my practice I shall see or hear, amid the lives of men, which ought not to be noised abroad—as to this I will keep silence, holding such things unfitting to be spoken.

"And now if I shall fulfill this oath and break it not, may the fruits of life and of art be mine, may I be honored of all men for all time; the opposite, if I shall transgress and be forsworn."

The best Greek text (from which the foregoing translation was made) is that of E. Littré, "Œuvres complètes d'Hippocrate," etc., tome 4, Paris, 1844, pp. 628 to 632.

Many commentaries have been published upon the oath. Among these, special mention is deserved by Littré's Argument, *l. c.*, pp. 610 to 625; and by the notes of C. Daremberg, "Œuvres choisies d'Hippocrate," seconde édition, Paris, 1855, pp. 1 to 11.

The following matters require discussion, more or less brief:

Hygeia and Panacea were daughters of Æsculapius.

The distinction between "precept" and "discourse" (παραγγελίης τε καὶ ἀκροήσιος) has not been explained satisfactorily.

"Suppository" is perhaps as nearly equivalent as possible to the Greek word πεσσός, which doubtless means, in the oath, a sort of medicated pledget to be withdrawn after a longer or shorter time. Many formulæ for making such, for various purposes, are given in the Hippocratic collection.

The words "destructive suppository" (πεσσὸν φθόριον) refer to abortion. A parallel and fully developed phrase, viz., "a wine destructive to embryos" (φθόριος ἐμβρύων οἶνος) occurs in the Materia Medica of the later Greek physician Dioscorides, of the first century A.D. (Lib. v., cap. 77, ed. Sprengel, vol. i., p. 734). Although abortion is abjured without qualification in the oath, there were probably Greek practitioners of the time of Hippocrates who made a distinction similar to the modern one between justifiable and criminal abortion; for methods of emptying the uterus are frequently and quite simply referred to in the Hippocratic collection, though often expressly aimed at embryos styled "dead" or "livid" or "motionless" or "stricken" or "apoplectic."

But there is also good reason to believe that, in Hellas, the accepted line between guilt and innocence in the matter of abortion did not always coincide with that drawn nowadays. The clear recognition of the fact that the early embryo is from the instant of conception a human being, truly alive and possessing the right to live, even before the "quickening"—this doctrine is entrenched in a maturer knowledge of physiology than the ancients could command. In the ideal State discussed in Plato's dialogue of "The Republic," certain embryos irregularly begotten were to be made away with before birth (ed. Stephanus, p. 461c). Plato was a younger contemporary of Hippocrates, and Plato's pupil, Aristotle, was born a few years before the death of the great physician, and was himself an Asclepiad, *i.e.* a physician's son. Aristotle, in his "Politica," expressly recommends abortion in order to limit the number of children, but enjoins the procuring of it "before the advent of sensation and life." The presence of these he formally makes the criterion of "the hallowed" and the reverse in this matter (Politica, vii., cap. 16, ed. Ac. Boruss., p. 1335, b 19 to 26).

In the embryological treatise "On the Nature of the Child" in the Hippocratic collection, the author, who may not have been of Cos, but possibly an adherent of the rival school of Cnidos, describes a certain case as one of abortion at the sixth day deliberately procured by himself. The circumstances are given in detail, and plainly stamp the case as criminal according to modern ideas; but the author relates it without a trace of guilty consciousness, adhering, one may conjecture, to the doctrine of morals set forth by Aristotle (Hippocrates de Nat. Pueri, § 13, ed. Littré, vii., p. 488). The following striking passage both shows us "strict constructionists" of the Hippocratic oath nearly 500 years after the death of Hippocrates, and sets forth explicitly, as current eighteen centuries ago, a view of the morals of abortion closely akin to that of modern physicians. The Greek gynecologist Soranus of Ephesus was a practitioner at Rome under the emperors, not far from the time when Juvenal was scourging its vices with his satires in the earlier years of the second century A.D. Referring to abortion, Soranus writes:

There is a disagreement; for some reject destructive practices, calling to witness Hippocrates, who says, "I will give nothing whatever destructive," and deeming it the special province of Medicine to guard and preserve what Nature generates. Another party maintains the same view, but makes this distinction, viz., that the fruit of conception is not to be destroyed at will because of adultery or of care for beauty, but is to be destroyed to avert danger impending at parturition, if the uterus be small and cannot subserve the perfecting of the fruit, or have hard swellings and cracks at its mouth, or if some similar condition prevail. This party says the same thing about preventing conception, and with it I agree. (Translated by the present writer from the Greek of Soranus, Gynæciorum Lib. i., cap. 19, ed. Rose, p. 229).

The abjuration of lithotomy in the oath contains the only mention thereof made in the Hippocratic collection. The ancient practitioners of medicine freely practised operative surgery; and no certain cause can be assigned for their refusal to cut for the stone. It has been shrewdly guessed, however, that the cause lay simply in the formidable dangers of a rude and uncertain procedure.

As the Hippocratic oath still plays a part in medicine worthy of its character and history, it has been thought proper to end this article with one of the modern adaptations. At the annual commencement of Columbia University in the City of New York, the following oath is administered to the graduating class of its College of Physicians and Surgeons:

Candidates for the Degree of Doctor of Medicine:

You do solemnly swear, each man by whatever he holds most sacred:

That you will be loyal to the Profession of Medicine and just and generous to its members;

That you will lead your lives and practise your art in uprightness and honor;

That into whatsoever house you shall enter, it shall be for the good of the sick to the utmost of your power, you holding yourselves far aloof from wrong, from corruption, from the tempting of others to vice;

That you will exercise your art solely for the cure of your patients, and will give no drug, perform no operation, for a criminal purpose, even if solicited; far less suggest it;

That whatsoever you shall see or hear of the lives of men which is not fitting to be spoken, you will keep inviolably secret.

These things do you swear? Let each man bow the head in sign of acquiescence.

And now, if you shall be true to this, your oath, may prosperity and good repute be ever yours; the opposite, if you shall prove yourselves forsworn.

In this oath, the words "that you will be loyal to the Profession of Medicine, and just and generous to its members," are from a formula at one time in use at the above-named medical school; for the rest of the foregoing adaptation the present writer is responsible.

JOHN G. CURTIS.

Hirsch, August.—Born at Dantzic, Germany, October 4, 1817. He was a shopkeeper for several years before he began the study of medicine in the Universities of Leipzig and Berlin. He received his doctor's degree from the latter institution in 1843. In the hope that he might find employment in the English East India Service he began, in 1846, to devote a great deal of his time to the study of what Pagel terms geographical pathology. In 1848 he published,

in the *Hamburger medizinische Zeitschrift,* the results of this study; the article in question bearing the title: "Ueber die geographische Verbreitung von Malariafieber und Lungenschwindsucht und den räumlichen Antagonismus dieser Krankheiten." Then followed (in 1851 and 1855) two other articles of a kindred nature; and finally he published one on "Der Madura-Fuss, ein Beitrag zur Geschichte des pflanzlichen Parasitismus," 1863. In this same year he accepted a call to fill the Chair of Medicine in the University of Berlin. From this period onward Hirsch's contributions to medical literature became very numerous. It will suffice here to mention only his greatest work, that entitled: "Handbuch der historisch-geographischen Pathologie," 2 volumes, Erlangen, 1859–1864 (2nd edition, 1881–1886). An English translation of this work was published by the New Sydenham Society, in 1883. Hirsch died January 28, 1894, after a prolonged illness. A. H. B.

Hirudin is the active substance contained in leech extract. It has a specific action upon the coagulation of the blood causing the blood to remain fluid for an indefinite period whether added to blood inside or outside the body. It has toxic properties acting upon the respiration besides causing a rise of temperature and albuminuria. F. P. U.

Hirudinea.—Among the Annelida or segmented worms the leeches form a well-marked order. The body of the leech is elongated, usually flattened dorso-ventrally, and provided with a prominent terminal or subanal sucker, while many forms possess also an anterior or oral sucker. The bristles all but universally present in annelids are here wanting save in a single genus, and the metamerism of the body presents a poorly marked external aspect although actually highly developed. The rings which appear in external view are mere surface markings, and are variably related to the true somites. Of the latter there are always thirty-four (thirty-five), of which those in the central portion of the body possess the typical number of annuli, while the first few and last few manifest ordinarily a reduction from that number. Prominent papillæ may usually be observed on the dorsal surface in the form of six or eight longitudinal rows; these are metameric sense organs known as sensillæ, and the eyes which vary in number in different forms are anterior units in certain of the rows. The annulus bearing the sensillæ is now generally regarded as the central one of the typical three- or five-ringed somites, and is the only one present in case of those somites manifesting the extreme of reduction. The leeches are hermaphroditic and the two sexual pores lie in the midventral line, the male in front of the female orifice.

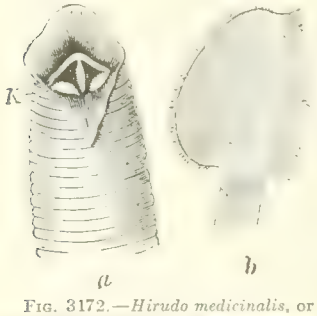

FIG. 3172.—*Hirudo medicinalis*, or European Leech. *a*, Ventral aspect of anterior end, showing an open mouth at the bottom of which the jaws, *K*, are visible. *b*, one of the jaws isolated, showing marginal denticles and muscles. (After Claus.)

Two subdivisions are recognized; the proboscis leeches (Rhynchobdellæ) without jaws and with colorless blood, and the Arhynchobdellæ which have no proboscis and possess red blood. Most human parasites fall in the latter suborder and in the family of the Gnathobdellidæ, or Round-jawed Leeches, which is characterized by three saw-toothed jaws in a simple pharynx (Fig. 3172); the typical somite has five annuli. Among the fresh-water leeches (Natantia), which have an eyeless ring between the third and fourth pairs of eyes, only the monostichodont forms (*i.e.*, those with a single row of teeth in each jaw) are important, and of these only two genera need be noticed here.

Hirudo L.—One hundred and one to one hundred and three rings with twenty-six metameres between the first pair of eyes and the sucker of which the first six and the last four are abbreviated. Buccal and postbuccal rings fused below; only three annuli in somite XXIII. Each jaw has from fifty to one hundred sharp-pointed teeth. Male genital pore between annuli 30 and 31, female between 35 and 36. First pair of nephridial pores ventral in ring 13, last in ring 93; seventeen in all.

Hirudo medicinalis L.—*Sanguisuga medicinalis* Savigny 1822, *S. officinalis* Savigny 1822, *H. officinalis* Derheims 1825. One hundred three rings. Somites VIII–XXIII each complete with five rings. Crop with ten pairs of lateral ceca, the last of which is longest and reflected and posterial. Upper lip of anterior sucker not divided by longitudinal groove on inferior surface. Length 100 to 200 millimeters; breadth 10 to 30 millimeters. Jaws large, each with 80 to 90 teeth. Color variable, darker above than below, dirty yellowish-brown in tone with tendency to gray or green; at the margin a bright yellow or brown band with black margins; on the back three more or less prominent red longitudinal bands spotted with black (Fig. 3173).

FIG. 3173.—*Hirudo medicinalis*, or European Leech. *A*, Dorsal aspect; *B*, ventral aspect. (After Railliet.)

This species is native in Europe, northern Africa and southwestern Asia, but at present is extinct in many regions and obtained by artificial culture or through importation only. Among the very numerous color varieties, as many as sixty-four being recorded by Diesing, two have been recognized as sub-species or varieties:

The Gray Leech, var. *medicinalis s. str.*, back greenish-gray with three russet-red lines on each side, of which the middle one, and often the inner also, shows a black spot on each metamere. Ventral surface greenish-yellow and spotted with black.

The Green Leech, var. *officinalis*, back darker green, often with black pigment more prominent, though red specimens also occur. Ventral surface almost entirely unspotted. A series of intermediate forms makes a distinction even between these two varieties difficult in many cases.

The leech sucks from four times its volume of blood for the young to three times in an adult, or from six to fifteen grams. If, however, the sucking leech be cut in two by the shears close behind the pharynx, the blood streams out in pronounced pulsations and, as the sucking action is not interfered with, a stronger or rather longer-continued blood extraction is caused. During the ordinary operation of sucking a leech gives off a large quantity of clear fluid which exudes from the skin in drops. It is not blood serum, as often supposed, but the secretion of the nephridial canals. While this exudation ceases at the end of ten days, the assimilation of the stomach contents of the leech demands from twelve to eighteen months. At the end of two months, however, the animal manifests

willingness to bite, but its full appetite is not yet restored. On the other hand, the leech can fast for two years or more and may be kept indefinitely without food in suitable leech jars. A fast of from six to eight months is necessary before reemployment; but the latter is not advisable. Before the third year of their growth leeches are not used for medicinal purposes, and from eighteen to twenty years has been put as the probable length of life. For the method of using leeches, see *Blood-letting*.

The leech was known to the ancients but not in great demand for phlebotomy until the XIX Century. The traffic grew until in 1832 France employed over fifty-seven millions of imported leeches. At that time not only leech gathering but even leech farming became a profitable industry. At one time the enormous demand for leeches reached, for example, 7,000,000 per year in London alone, but in recent years their use for therapeutic purposes has greatly diminished, no doubt largely as the result of occasional fatal cases and in spite of certain evident advantages for local affections. Fatal bleeding has been known where the bite opened a large vessel (*vena cruralis* or *jugularis*), or in internal organs where the leech, by careless application at the nasal fossæ, vagina, or rectum, has penetrated or been drawn too deeply into the organ. In order to guard against this leeches should be fastened in such cases by a thread passed through the middle of the posterior sucker.

The procedure of blood-letting, common up to a century ago, has been almost entirely abandoned. Recent experiments have demonstrated that this ancient practice exercises a favorable effect in decreasing abnormal permeability of the vessels so that the repeated withdrawal of blood from the circulation may produce a response of therapeutic value to the organism. Blood-letting seems to rest on a sound experimental basis in conditions which display undue formation of transudates and exudates, as in pneumonia and pleurisy.

Haycraft showed that leech heads have the property of retarding coagulation of blood and later experimenters have prepared in various ways an extract that keeps well and insures constancy as well as rapidity of physiologic action. By the use of such an extract it is apparently possible to reduce the number and extent of fibrinous adhesions in rabbits and guinea pigs.

Leeches are normal hosts for parasitic organisms, especially of the flagellate type of Protozoa. Some of these have been shown to belong exclusively to the leech, but others are now known to be developmental stages in the life cycle of species that at other periods infest other higher animals and are transmitted by leech bite. The leech thus plays a rôle in the life history of the parasite similar to that long recognized in some blood-sucking insects, *e.g.* ticks, mosquitos, and flies. In some cases at least the leech is a true necessary host and the fishes or amphibia which harbor the parasite in its other phase owe their infection to leech bite. The leech may also be the final host and the turtle serve as intermediate host for other flagellate parasites. This phase is not of sinister significance to the human species since the parasitic forms are not capable of developing in man even if introduced by chance into the human blood. Other recent experiments show that the transfer of disease germs from man to man is possible though clearly very unlikely and the result only of especially unfavorable circumstances. The long rest of the leech after feeding is many times greater than any period during which germs of any sort have been found alive in the intestine of the leech. *Spirochæta obermeieri* can thus maintain itself in the medicinal leech only up to 100 days at the most, as was determined experimentally in Warsaw during a long epidemic of relapsing fever in 1908. Thus the danger of infection through its use in phlebotomy may be set aside from consideration.

Where native, these, like other large leeches, attack men and animals invading swamps and pools, and in recorded instances with fatal results to children or young animals.

Hirudo troctina Johnson 1816, often confused with the medicinal leech, is distinguishable by its smaller size, 80 to 100 millimeters in length by 12 to 18 millimeters in breadth, and especially by the scantier number of teeth, about seventy, in each jaw. It is native in northern Africa and Spain, perhaps also Italy and Sicily, and is exported in large numbers to France, England, and America. In power to extract blood it is much inferior to *H. medicinalis*.

Hirudo nipponica Whitman 1886, also smaller in size than *H. medicinalis*, is common about Tokyo, Japan, and in other parts of the island. Its habits and use conform closely to those of the continental species. Other species of similar habit are reported from different regions of the Orient; they are, however, only poorly known.

The genus *Limnatis* may be distinguished from *Hirudo* by the papillæ on the jaws and by the ventral furrow traversing the entire length of the anterior lip of the oral sucker. One species, *Limnatis nilotica* Sav., demands brief notice. It is native in the circummediterranean region, and in some places is so abundant as to become a veritable pest. Especially the young, described by Moquin-Tandon as *Sanguisuga ægyptiaca*, are often swallowed accidentally in drinking and may remain for a long time fixed in pharynx, choanæ, esophagus, trachea, or even stomach. The species plays accordingly an important rôle in diseases of man and domestic animals in northern Africa during the hot season. European soldiers in garrison, and even natives, in spite of their precautions, suffer from the leech, which evokes by its presence both local and general symptoms of serious character if assistance is not speedily afforded. With the removal of the worms rapid and complete healing of the wounds and disappearance of secondary symptoms occur almost immediately and without exception.

Cases are recorded from Italy, Greece, Turkey, Asia Minor, Palestine, Egypt, Algiers, Tripoli, Spain and the Balearic Islands. More recently they have also been reported from India. Such cases are most common in children and youths, though by no means wanting among adults. Masterman has recently reported a series of over forty cases from Palestine, among them being two that were fatal. The slight but greatly prolonged hemorrhages are accompanied by cough, dyspnea, cyanosis and even entire loss of voice.

The natives spear the leeches with a sharp thorn; their removal is not difficult with instruments appropriate to the location of the parasite, but Masterman advises preliminary spraying with cocaine or the application of a stronger solution on a pledget of cotton. Precaution must be exercised to prevent the leech from dropping into deeper and inaccessible locations after its hold is released. In general the most distressing cases are those in which the leech occupies the deep-lying situations. When feeding normally the leech becomes satiated in a brief time and drops off. For some reason this is not the case when it occupies an internal position. Its presence there is accompanied by a slow bleeding and extends to two weeks, a month, or even in one case a full year without the animal becoming gorged or displaying any tendency to desert its place voluntarily.

This leech can pierce only the mucous membranes of higher animals, and its inability to penetrate the external skin, even of children, has often been demonstrated. Other species of this genus have a more powerful bite, and are used especially in the East for medicinal purposes, even though they take up less than half as much blood as *Hirudo medicinalis*. In this country *Macrobdella decora*, one of the large native leeches, is employed in some places for blood-

letting; it may be recognized by the following description:

Macrobdella Verrill 1872. Cephalic lobe smaller than in *Hirudo*. Annuli 103; at least four in somite XXIII. Neither buccal nor postbuccal annuli united on the ventral side. Both genital orifices in somite XI., and behind them a group of prominent copulatory glands.

Macrobdella decora Verrill.—*Hirudo decora* Say 1824, *H. decora* Leidy 1868. Jaws with about sixty-five teeth, copulatory glands opening by four pores in a quadrate figure on the last annulus of XIII. and the first two of XIV. The first annulus of XXVI. is divided marginally and sometimes also dorsally into two annuli.

This species is widely diffused in fresh waters of the United States, having been reported from Maine to Minnesota and from Pennsylvania to Kansas. It is frequently used instead of imported leeches by physicians and is said to be equally efficacious, although its capacity is somewhat smaller, only about five grams. It is so powerful, however, that serious results have followed its attacks upon the legs of children wading in its haunts.

Among the land leeches which form a special section, Reptantia, of this family, and are distinguished by the absence of an eyeless ring between the third and fourth pair of eyes, a few forms deserve brief mention.

Hæmadipsa Tennent. Body almost round, sucker separated only by a slight constriction. Near the sucker auriculæ with the pores of the last pairs of nephridia. Typical metamere with five annuli.

Hæmadipsa zeylanica Moq.-Tand.—*H. japonica* Whitman. Length 20 millimeters, or in extended form 60 millimeters, diameter of body behind 6 millimeters, in front 2 millimeters; sucker 5 to 7 millimeters in diameter. Annuli ninety-seven; male genital pore between annuli 30 and 31, female between 35 and 36. In each jaw ninety incurved teeth.

The animal, when gorged, has the form of a flask of about 10 millimeters in diameter at its largest part, while the neck measures only 2 or 3 millimeters in thickness. The color is exceedingly variable, and yet five or six varieties may be recognized, one of which, var. *japonica* Whitman, known in Japan as the mountain leech, is common in the entire Indomalayan region, China, and Japan. It has long been known on the Island of Ceylon, where it forms a veritable pest to natives and Europeans alike. The leeches appear in immense swarms, particularly in moist regions and during the rainy season, and at all levels from the coast up to 4,000 feet, although they occur even as high as 15,000 feet in the Himalayas. During the dry season they hibernate in the earth; at other times they live in moss among stones and on shrubs and trees. The approach of large animals brings them out in myriads; they move with surprising activity, and springing on the unfortunate passer-by they suck often for hours before falling off. No clothing is close enough to protect man from their attacks, and during army maneuvers they have inflicted large losses on European troops, attacking the soldiers even when asleep. Accounts of travel in Ceylon abound in narratives of the ferocity of these pests, and recent writers from the Philippines comment on their activity in that country in equally forcible terms. It is probably this species, and very likely the variety *japonica*, which is reported by Blanchard as abundant in the Philippines, to which the trouble is due, although other species of *Hæmadipsa* manifest, no doubt, similar habits of life.

The bite is not poisonous, as often maintained, but the large number of wounds and careless treatment afford abundant opportunity for secondary infection of a serious character. Among the natives of Ceylon one may see many deformities induced by these leeches, which are accordingly feared more than serpents and carnivores.

An allied form, *Phytobdella meyeri* R. Bl., is also recorded from Luzon.

The family of the Rhynchobdellidæ, or proboscis leeches, is characterized by a protrusible pharynx, while the typical metamere consists of three annuli and jaws are lacking. Few of these forms are able to penetrate the human skin, but among those of sufficient power are especially American forms, which appear as occasional parasites of man and in some regions are used for therapeutic purposes. The two species of importance are both members of the following genus, which is restricted to the warmer regions of the American continent:

Liostoma Wagler 1831—*Hæmenteria* de Fil. 1849. Body broad and flattened; back covered with many prominent papillæ; the first and third ring of each somite from VI. to XXII. inclusive split on the ventral surface so that on the ventral surface the space occupied by five pseudo-annuli corresponds to that occupied by the three adjoining dorsal annuli. Male genital pore between annuli 26 and 27, female between 28 and 29. Two pairs of eyes so closely set that they appear as a single pair.

Liostoma Ghilianii R. Bl.—*Hæmenteria ghilianii* de Fil. 1849. Length of alcoholic specimen 190 millimeters, breadth 100 millimeters, corresponding to a probable length while living of 350 to 400 millimeters. Annuli seventy, together with three preocular; the first seven annuli form the oral sucker.

This giant form inhabits the basin of the Amazon and the swampy regions of Guiana. Blanchard reports that it attacks horses and cattle, and a few individuals are sufficient to kill even a full-grown animal.

Liostoma coccineum Wagler 1831—*Hæmenteria officinalis* de Fil. 1849, *H. mexicana* de Fil. 1849,

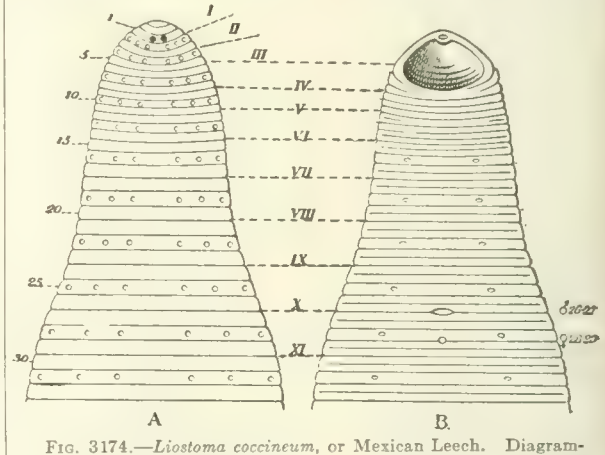

Fig. 3174.—*Liostoma coccineum*, or Mexican Leech. Diagrammatic view of anterior somites, *A*, from dorsal surface with eyes and sensillæ, *B*, from ventral with nephridial and sexual pores. (Modified from Blanchard.)

Glossiphonia granulosa Jimenez 1865. Length 80 millimeters, breadth 22 millimeters. Annuli seventy, with two preocular; the first six annuli form the oral sucker (Fig. 3174).

The range of this species extends from Mexico to Paraguay through Central and South America. In Mexico it is universally used as the medicinal leech. In some instances, however, its bite appears to be accompanied by serious results. There are noted almost immediately a feeling of general lassitude and an unpleasant itching and twitching, succeeded soon by general urticaria, and in a short time apoplectic symptoms are manifested; but cases occur in which the cerebral congestion or the urticaria is wanting. Most authors incline now to the belief that these symptoms are due to the salivary secretion poured into the bite by the leech, and yet it seems also clear that some

predisposition on the part of the individual is also a prerequisite. Brandes suggests that the symptomg of poisoning are manifested only in persons exhibitins hyperesthesia, and attributes the rare cases of serious illness following the application of *Hirudo medicinalis* in Europe to the same sensitive constitution. Compare in this connection the effects produced by the bite of *Argas*, as reported by Brandes and noted in the article *Arachnida*, Vol. I., p. 437.)

In spite of these accidents this is actually the only species used for medicinal purposes in Mexico, sufficient evidence of its generally satisfactory character In some provinces (Guadalajara) the leech is regularly cut in two after it has taken hold in order to measure definitely the quantity of blood extracted.

HENRY B. WARD.

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Also shorter papers by the same authors, Leidy, Loeb, J. P. Moore, and others.

Hirudo.—A genus of leeches. *H. medicinalis* and *H. troctina* are commonly used for medicinal purposes in Europe. Several other species are known in Asia, Africa, and Australia. See *Hirudinea*. A. S. P.

His, Wilhelm.—Born in Basel, Switzerland, on July 9, 1831. He began his medical education in his native city in 1849. In 1850 he went to Berlin, where

FIG. 3175.—Wilhelm His.

he attended lectures on embryology by Johannes Müller and Remak, which was the foundation of the wonderful work he afterward accomplished. Two years later he went to Würzburg, where he remained through three terms, working in the laboratories of Virchow. He returned to Basel in 1854 to complete his examinations and then proceeded to Paris. Here he met Claude Bernard and Brown-Séquard, and worked for a length of time in the laboratory of the College of France. In 1857, when twenty-six years of age, he became a Privatdocent under Professor Meissner, and later in the same year, on the promotion of Meissner to Freiburg, His followed him as Professor of Anatomy and Physiology in the University of Basel. He remained in the University of Basel until 1872, when he received the appointment of Professor of Anatomy and Director of the Anatomical Laboratories in the University of Leipzig. The new buildings of the institutes of Leipzig were built under his directions and have been regarded ever since as models in such construction. In 1897 he attended the summer meeting in Dublin of the Anatomical Society of Great Britain and Ireland, and delivered an address in the theater of the Royal Dublin Society on the development of the brain. His lecture was illustrated by blackboard sketches which were photographed afterward and reproduced in the Transactions of the Royal Academy of Medicine in Ireland. His retained his professorship in the University of Leipzig until his death on May 1, 1904.

His is best known in England and America as one of the greatest of embryologists. He contributed much original work, however, to nearly every department of anatomy, and his original monographs and papers exceed over a hundred in number. Of his published writings the following are the more widely known: "Beiträge zur normalen und pathologischen Anatomie der Cornea," 1856; "Ueber die erste Anlage des Wirbelthierleibes," 1868; "Theorien der geschlechtlichen Zeugung," 1870; "Anatomie menschlicher Embryonen," 1880 to 1885. This work has formed the basis of all the subsequent text-books on embryology. In 1899 about the last of his writings "Protoplasmastudien am Salmonidenkeim" was published.

Aside from his active life connected with his professorship, His was one of the founders of the *Archiv für Anthropologie* and later of the *Zeitschrift für Anatomie*, which he edited until it was merged with the *Archiv für Anatomie und Physiologie*. He was also a prime mover in the endeavor to introduce a uniform anatomical nomenclature, now known as the Basle Anatomical Nomenclature or BNA.

E. L. J.

Histidine.—α-amino-β-imidazol propionic acid,

This is a product of the hydrolytic cleavage of proteins whether by acids or enzymes. It does not occur in the protamines with the excepion of sturine. Globin from horse-hemoglobin seems to be therichest of the proteins in histidine, being present there to the extent of over ten per cent. Histidine crystallizes in colorless plates, readily soluble in water, but less soluble in alcohol, and it possesses an alkaline reaction. It is one of the so-called hexone bases. F. P. U.

Histogaster.—A genus of mites. *H. spermaticus* usually feeds on vegetables but has been introduced by means of a catheter into man where it formed a cyst in the testis. See *Arachnida*. A. S. P.

Histological Technique.—Tissues may be studied in the fresh or living condition as well as after fixing and staining.

Living Tissues.—Protozoans and the smaller metazoans and plants lend themselves readily for microscopic study. Ameba, paramecium, diatoms are

readily procured and a drop of water containing them is placed upon a slide and a cover-glass applied. In this way their methods of locomotion, feeding, etc., can be studied and the effects of various reagents can be ascertained. In order to prevent crushing of the specimens, a hair may be placed under the edge of the cover-glass. The larger protozoans as the vorticella and stentor, and metazoans like the hydra are better studied upon a culture slide, or one provided with a space as shown in Fig. 3176. The object of

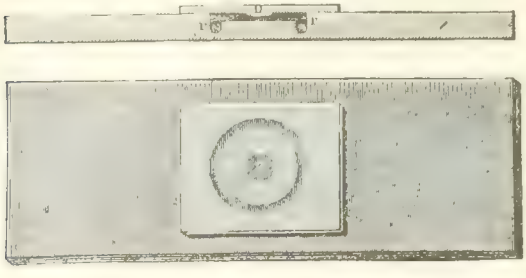

Fig. 3176.—Moist Chamber Slide.

so mounting is not to crush the organism and to allow it freedom of motion. Such a slide also serves as a moist chamber.

The *cells* of the various organs are readily obtained in various ways. After removal, the mucous surface of the organs, as stomach, intestinal tract, respiratory system, etc., may be gently *scraped* with a scalpel and the material so obtained mixed with a little decinormal salt solution upon a slide, covered and examined under the microscope. Another method of obtaining cells is to *brush* the surface gently under salt solution with a camel's hair brush, thereby removing the cells. Still another method is to *shake* a thin slice of an organ in a test-tube containing some salt solution. This agitation loosens the cells and they float in the salt solution and can be drawn off and examined.

In order to examine certain tissues, they must be *teased*. For this a couple of properly mounted needles (Fig. 3177) are used. The tissue, fibrous, muscle,

Fig. 3177.—Needle Holder and Needles.

tendon, etc., is placed upon a slide with a little salt solution or glycerin, and then gently torn apart with the needles. When this process has been carried so far that it is impossible to divided it any further, a cover-glass is applied and the individual fibers may then be studied. Some knowledge of the general structure of the tissue is required in order to tease properly, as for instance, muscle tissues should be teased parallel to the long axis of the fibers, otherwise these will be torn across. The operation is facilitated if a suitable background is utilized.

Thin tissues and membranes like the *peritoneum*, *omentum*, or *mesentery* may be spread out carefully upon a glass slide, covered with salt solution and a cover-glass when they are ready for study.

Ciliary action may be observed in a number of preparations. A thin piece of mucous membrane of the palate of a frog mounted in normal salt solution will exhibit this phenomenon or the gill plates of a mussel or oyster may be dissected out and mounted in the same manner. The ciliated cells of the latter animals possess much longer cilia than those of the frog. The direction of the current produced by the ciliary action may be observed by placing a small fragment of tissue upon the cilia and these will be seen to move this fragment from one area to another in a direct line.

The *circulating blood* may be examined in the tail of the tadpole, the mesentery or web of the frog, or in the mesentery of the guinea-pig.

If the *tadpole* is used, it is best placed in a holder devised by Schulzer (Fig. 3178). The head is placed under the edge *a* and the tail is spread out upon the

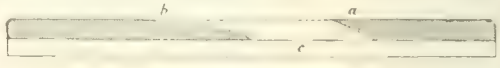

Fig. 3178.—Schulzer's Larva Holder

beveled edge *b*. If necessary a few drops of ether are added to the water in order to keep the animal quiet. If the specimen is to be studied for an extended period, the water should be replaced from time to time as it evaporates.

Frog's Web.—If the web of the foot is to be utilized, then a microscope with a large stage and a thin cork plate with a fifteen-millimeter hole is required. The frog is loosely wrapped in a towel and tied to the stage, so that the web will be over the opening in the stage beneath the objective. The cork plate is so placed that its aperture is over the stage opening and the web is then stretched and the toes tied to pins stuck into the cork. The flow of blood is very readily followed under the two-third-inch objective.

In order to prevent movements of the frog, it is advisable to paralyze it with curare especially in studying the flow of blood in the mesentery. From time to time it may be necessary to administer a small amount of ammonia gas to stimulate the circulation.

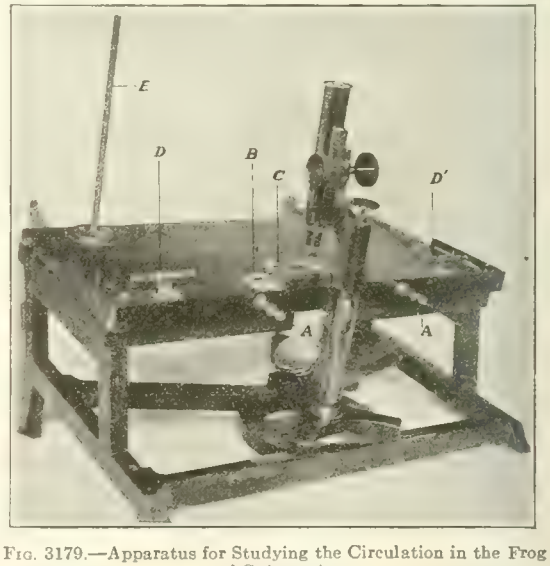

Fig. 3179.—Apparatus for Studying the Circulation in the Frog and Guinea-pig.

Mesentery.—If the mesentery of the frog or guinea-pig is to be utilized, the animal must first be paralyzed with curare. In the male frog one-fortieth to one-sixtieth of a grain is administered by making a nick in the skin of the dorsal surface of the body, and forcing the tablet in and allowing the lymph to dissolve and distribute it. The paralysis is complete. In the guinea-pig it is best administered by injecting a one-twentieth of one per cent. solution hypodermically. Upon paralysis the abdominal cavity of the frog is

carefully opened by an incision about twenty millimeters long, a coil of the intestine withdrawn and placed over the opening in the cork so as to bring the mesentery under the objective. The specimen may now be examined. If the guinea-pig is used, the abdominal hair is thoroughly moistened, so as not to get into the incision. An area over the middle of the abdomen is clipped and an incision made in the midline to the left of the umbilical region. A coil of the small intestine is then drawn through the opening and fastened to each plate as above. When the mesentery is used, it must be kept constantly moist by dropping warm normal salt solution upon it.

An apparatus shown in Fig. 3179 is well adapted for this work. This consists of a microscope mounted upon a large inclined table with an adjustable top. The movable top is supplied with a rim around three sides and outlet tubes (A, A) to carry off the irrigating fluid. Beneath the microscope is a chamber (c) with a central hole filled in with glass disc to permit the transmission of light from the mirror to the microscope. This chamber is fitted with two inlet and two outlet tubes and may be utilized as a cold or warm chamber by permitting water of the desired temperature to flow through. To the upright rod an irrigation bottle as shown in Fig. 3180 may be clamped and connected with one or both tubes D,D'. If D is used, the bottle is connected to the left end; to the right end of D is attached a rubber tube with a glass nozzle that reaches to the specimen to be irrigated and the irrigation fluid is carried off into containers placed

Fig. 3180.—Irrigation Bottle to be attached to Rod of Fig. 3179.

under the tubes A,A. A cork plate about six inches by three inches by one-half inch is required. This should have a half-inch hole in the center to fit over the glass of the chamber C; in addition two slits should be cut in so that the plate can be adjusted around the bodies of the two clips of chamber C. These clips hold the plate in position. If the web of the frog is to be studied the curarized frog is so placed to the right that the web can be stretched over the hole on the cork plate and the digits are separated and tied to pins stuck in the plate. The same procedure applies if the mesentery is utilized.

In order to study the effect of various *reagents* special apparatus is required. For *heat* or *cold* that shown in Fig. 3181 is excellent. This consists of a hollow metal slide provided with a central opening c for the transmission of light; B and B' represent inlet and outlet, while at the upper edge is seen the thermometer. This is adapted to the use of either hot or ice-water. In order to watch the effect of liquid reagents upon organisms under a cover-glass, a little of the reagent is placed at the side of the cover-glass and a piece of blotting paper held at the opposite side; as the blotting paper absorbs the water, the reagent is drawn under the cover-glass to the organisms.

For *gases* the combined warming and gas chamber of Stricker, Fig. 3182, is suitable. It consists of a rectangular piece of ebonite, E, E, fixed to a brass plate that rests on the stage of the microscope. On the upper surface of the ebonite is a brass plate, P, with an opening in the center, C, leading into a brass tube, closed below by a piece of glass. For heating, the copper wire is placed on the tube a, the temperature of the plate being indicated by the thermometer t.

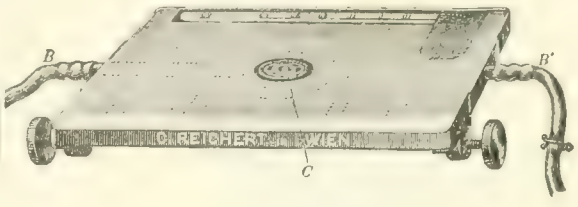

Fig. 3181.—Warm Stage

The gas is conducted into the chamber by the tube a', while a serves as an exit.

For long-continued observations at an elevated temperature Zeiss' warm chamber (Fig. 3183) for enclosing the microscope should be employed.

Jentzsch (1910) of Wetzlar has devised a number of electrically heated stages for the purpose of studying the changes in objects at various temperatures. These can be clamped upon the stage of a microscope and the temperature range varies from moderate to 560° C. (used in mineralogy and petrology). For use with high temperatures he devised a special apparatus for the protection of the objective of the microscope

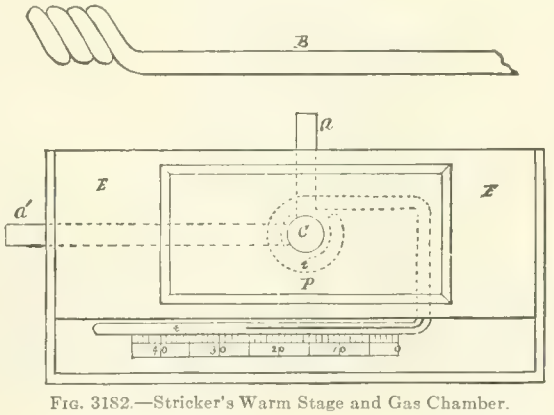

Fig. 3182.—Stricker's Warm Stage and Gas Chamber.

Application of Electricity.—For the application of the electric current to specimens, the slide shown in Fig. 3186 will answer as well as a more complicated piece of apparatus. This can be made as follows:

Take a glass slide 27×127 millimeters, and cover the surface with gold size; press the moist surface firmly down on gold leaf or tinfoil; allow it to dry, and then scrape away the metal so as to leave the two triangles e, e', with an interval, a, between their apices, of about five millimeters for the object. The specimen is placed at a, and covered with a cover-glass. For transmitting the current the ends of the slide are clamped by the clips c, c', to which the wires leading from the battery are attached.

In Fig. 3187 is represented a combined moist chamber and electric slide. The slide, s, is covered with tinfoil, f, on its upper and lower surfaces, the foil on the upper surface being carried to the upper edge of the glass cell, c, which is cemented to the slide. The slide is placed on the copper supports, K, K, that are

attached to the stage, *P*, if it be a glass one; if not, they must be insulated by strips of hard rubber. Two small strips of foil are cemented to the cover-glass, leaving a space of five millimeters between the ends. The bottom of the cell is filled with a few drops of water; the specimen is placed on the cover-glass, in contact with the tinfoil, and the cover is inverted and placed on the cell, *c*, so that the foil comes in contact

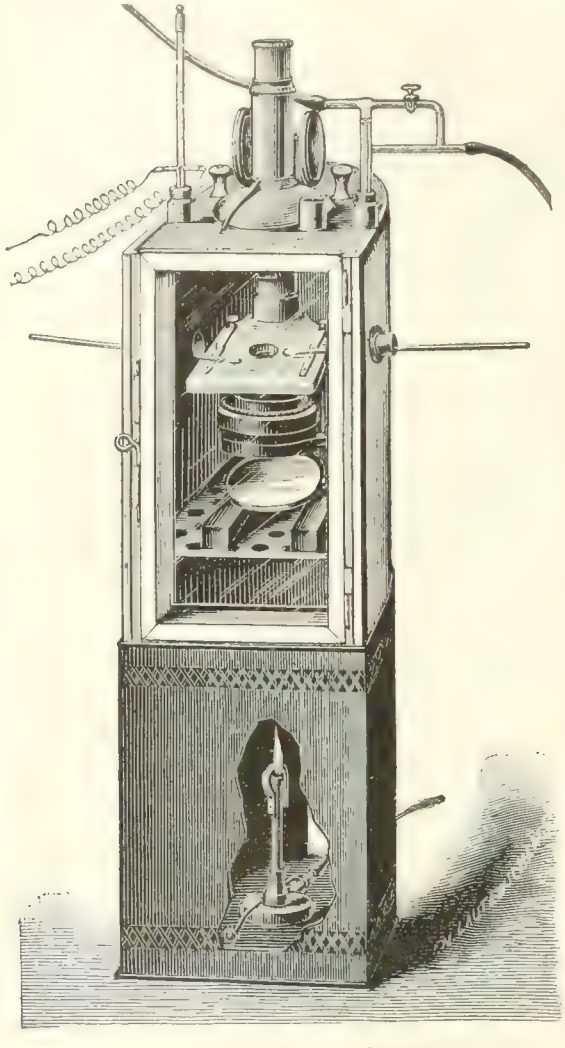

Fig. 3183.—Zeiss' Warm Chamber.

with that covering the cell. The electric current is conducted to the specimen through the metal supports by wires placed in the holes in their ends.

Compression.—By making pressure on the cover-glass, especially after maceration of the specimen, one is often able to separate the elements. This pressure can be made with the handle of a teasing needle, but it is apt to be unequal, and there is danger of breaking the cover and thus destroying the specimen. It is better to use an instrument called a compressorium, constructed especially for this purpose. In Fig. 3188 is shown one form invented by H. Jung, of Darmstadt.

The plate *A* is attached to the stage of the microscope by the catch *n* and the two screws *s*, *s*. On this plate is a double lever,one arm of which has a movable ring, *R*, and adjusting screw, *St*, and the knob *K*. The two levers are so connected with the bent piece *C* that when *K* is pressed down the ring *R* is also pressed toward the stage plate. Conversely, an upward movement of the knob, produced by the spring *F*, raises the ring. For use as a compressor the screw S_1 is loosened, and *St* screwed down until the desired degree of pressure is obtained. This apparatus can also be employed for another useful purpose, viz., beating. The process of beating is often resorted to for the purpose of isolating cells, tissue, etc. In using the instrument for this purpose the screw *St* is so adjusted that the ring

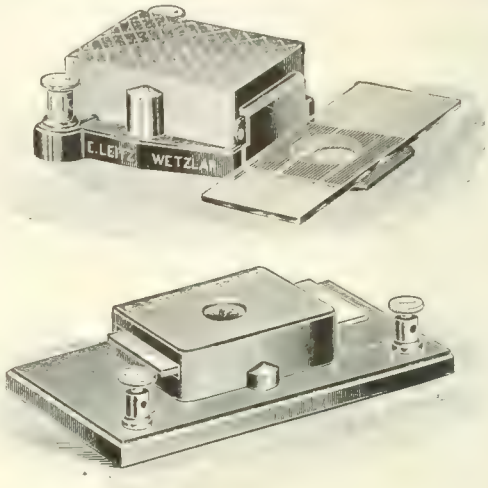

Fig. 3184.—Electrically Heated Stages. (E. Leitz.)

R lies close to a large and thick cover-glass covering the specimen, and S_1 is turned so that the lever can move but slightly. By quick and continuous movement of the lever, and the changing pressure on the cover-glass thus produced, tissues (after maceration) can be easily dissociated. When the cells are isolated they can be made, by a slower movement of the lever, to move about in all directions, so that they can be observed from all sides.

Fig. 3185.—Objective Protector.

Fresh tissues must be examined in a medium that will produce no visible alteration called in *indifferent solution*. There are a number of these.

Indifferent Solutions.—Decinormal Salt Solution.—Dissolve 7.5 grams of pure sodium chloride in 1,000 c.c. of distilled water. This solution represents practically the density of the blood and the sodium chloride content. A few drops of Lugol's solution added to the stock solution prevents the growth of moulds.

Aqueous Humor of the Eyeball.—This is obtained by puncturing the cornea of a recently killed animal and

Fig. 3186.—Gold-leaf Electrodes.

collecting the escaping fluid which is practically lymph.

Blood Serum.—This is obtained by collecting the blood of a recently killed animal in a cylindrical container and allowing it to coagulate. As soon as clotted, separate the upper edge of the clot from the container and allow to stand twenty-four hours. As the fibrin contracts, the clot sinks and the serum floats and this clear liquid may be siphoned off without disturbing the clot. It may be used in the same way as normal salt solution, or aqueous humor. This serum may be

iodized by adding 10 c.c. of a tincture of iodine to 1,000 c.c. of serum.

Pericardial fluid, or *serous fluid* from any of the large serous cavities of the body may be utilized if fresh.

Artificial serum may be made by adding one part of egg albumen to nine parts of normal salt solution. After solution of the egg albumen is effected the whole is filtered.

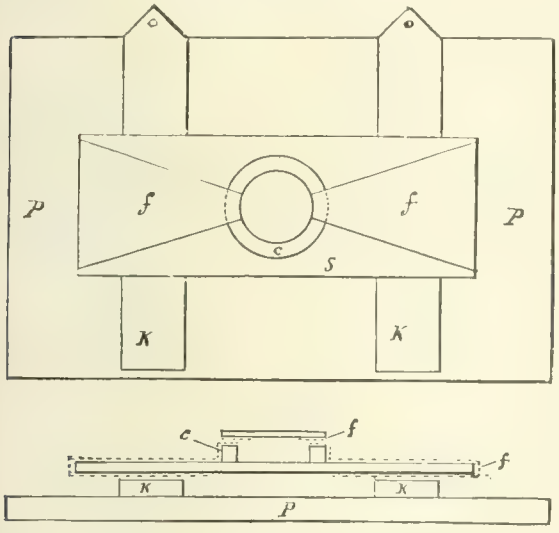

Fig. 3187.—Electric Slide and Moist Chamber.

Kronecker's Fluid.—This consists of sodium chloride 6 grams, sodium hydrate 0.06 gram, distilled water 1,000 c.c.

Solution of Ripart and Petit.—This is composed of copper chloride 0.3 gram, copper acetate 0.3 gram, camphor water 75 c.c., distilled water 75 c.c., crystallized acetic acid 1 gram. This solution will be yellow after mixing, but in the course of a few hours, it will be clear and should then be filtered.

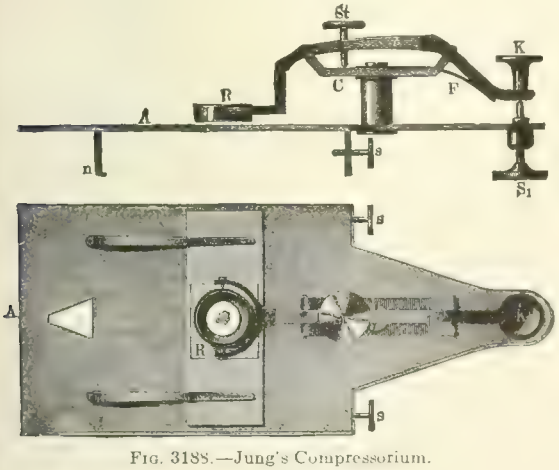

Fig. 3188.—Jung's Compressorium.

Fresh tissue may be sectioned for study by the use of a *double knife*, or by *frozen sections* made with a freezing microtome. If the double knife is used, that of Valentine (Fig. 3189) is recommended. This consists of two parallel blades attached to each other at their lower ends by a hinge; at *a* is a screw sliding in a slot. By means of this the blades may be approximated or separated. With the blades set for a desired thickness, the knife is forced through an organ thus retaining a thin section thereof between the blades. After the knife is withdrawn, the blades are separated by sliding back the screw *a*. The section is then floated off in normal salt solution and is then ready for examination.

Maceration.—Another means of separating tissues is by the means of various reagents that effect a *dissociation*. These reagents soften or dissolve certain tissues while others are unaffected and often the unaltered elements can be isolated by shaking, compression or other mechanical methods. The most important solution will be given.

Dilute Alcohol Thirty Per Cent. (Ranvier).—This consists of one part of ordinary ninety-five per cent. alcohol and two parts of distilled water. Small pieces of

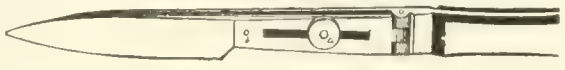

Fig. 3189.—Valentine's Knife.

tissue are placed in this solution for twenty-four hours and if not softened sufficiently the solution is renewed and allowed to act another twenty-four hours. It is best used for isolating epithelial tissues and the results may be bettered by fixing the pieces of tissue in one-half per cent. osmic acid solution for a few hours before macerating.

Chromic acid one-tenth per cent. to one-fifth per cent. is useful for isolating epithelial cells. This requires one to three or four days to act.

Hydrochloric Acid Twenty to Thirty Per Cent. Aqueous Solution.—Place small pieces of tissue therein in from twenty-four to forth-eight hours and wash thoroughly. This is especially adapted for isolating uriniferous tubules as it dissolves the interstitial tissue. The tubule may then be mounted in glycerin jelly. If used in the strength of 1 to 250 parts of water, it will separate the voluntary striated muscle fibers at its discs.

Potassium hydrate as a twenty to forty per cent. solution acts in fifteen minutes to an hour for cells of the nails, hairs and epidermis. If involuntary or heart muscle is used, small cubes of the tissue are placed in a large quantity of the reagent and shaken. When the dissociation has been accomplished the tissue is transferred to a saturated aqueous solution of potassium acetate to neutralize the hydrate. Later they are washed with water and may then be stained for twenty-four hours in alum carmin, washed with water and mounted in glycerin.

Sodium chloride used in a *ten per cent.* aqueous solution is useful in isolating white fibrous tissue. It requires two to three days to act. Carnoy recommends a trace of osmic acid. Sodium chloride solution is also useful in the study of red blood cells, but in different percentages. The following are recommended: For human blood, 0.9 per cent; frog's blood, 0.64. per cent.; selachians, 1.5 per cent. to 2.5 per cent., according to the species.

Nitric acid in a 10 *per cent. to* 20 *per cent.* aqueous or physiological salt solution may be used to isolate *muscle fibers*. Small pieces are allowed to remain in it for twenty-four to forty-eight hours, washed in water and mounted in glycerin. To study the arrangement of heart muscle fibers, J. B. MacCallum recommends the following: nitric acid 1 part, glycerin 2 parts, distilled water 2 parts. Small pieces of tissue remain in this solution from eight hours to several days and are then transferred to a five per cent. aqueous solution of glycerin.

For isolating *nerve fibers* for measurement, Schwalbe uses a twenty per cent. solution. Maceration is carried on at a temperature of 40° C. for twenty-four hours and the tissues then washed with water. Although the fibers do not shrink they become brittle.

Landois Solution.—This consists of the following:

Sat. sol. of neutral ammonium chromate 5 parts, sat. sol. of potassium phosphate 5 parts, sat. sol. of sodium sulphate 5 parts, distilled water 100 parts. This solution requires from three to five days for small pieces of tissue, which are then transferred for twenty-four hours to a solution of ammonia carmin diluted with one volume of the macerating liquid. This is recommended for all tissues, but especially for nerve tissues.

Concentrated sulphuric acid is used to isolate the keratinized cells of the epidermis, nails and hair.

Sulphuric Acid (Ranvier).—Place tissues for twenty-four hours in thirty grams of water containing four to five drops of concentrated sulphuric acid and then shake. This solution is recommended for nasal mucosa, crystalline lens, retina, etc.

Odenius recommends a solution of three to four grains of "English sulphuric acid" to an ounce of water for the study of nerve endings in tactile hairs. The hair follicles are macerated from three to fourteen days.

Nitric Acid and Potassium Chlorate (Schultze).—Powder the potassium chlorate and add enough nitric acid to make a paste. Imbed the tissue in this for several hours, transfer to a test-tube of water and shake. The fibers are then completely isolated. This is useful in the study of the branched muscle fibers of the frog's tongue.

Lysol (Reinke) is used either in a ten per cent. solution in distilled water or in water with alcohol and glycerin. It acts in a few minutes and is recommended to spermatozoa of the rats, cortical cells of hairs and the epithelial cells of salamandra.

Digestion Method.—Digestion in organ juices serves to dissolve out certain elements sooner than others, thus serving to isolate various tissues. The chief solutions are *gastric juice* (or *pepsin*) and *pancreatic juice* (*trypsin* or *pancreatin*). Tissues for digestion should be fresh or fixed in alcohol only.

Pepsin digests collogen substance and mucin readily and elastin slowly; nuclein is not at all or slowly affected and keratin, neurokeratin, chitin, fats, and carbohydrates not at all.

Pancreatin (*trypsin*) digests elastin, mucin, and nuclein readily; collagen substance, reticulin, chitin, keratin, fats, and carbohydrates are not affected.

The tissues to be digested are placed in the solution and container placed in an incubator at 37° C. for several hours. The process may be carried on in a warming chamber if sections of tissue are utilized.

Kuskow's solution consists of 1 part of pepsin dissolved in 200 parts of a three per cent. solution of oxalic acid. This must be freshly prepared and pieces of hardened ligamentum nuchæ are allowed to remain in it from ten to forty minutes.

Bruecke's Fluid.—Glycerinated extract of pig's stomach 1 volume, 0.2 solution of HCl 3 volumes, thymol a few crystals.

Bickfalvi's Solution.—One gram of dried mucosa of pig's stomach, 20 c.c. of a 0.5 per cent. solution of hydrochloric acid; place in an incubator for three to four hours and filter. Macerate for one-half to one hour.

Pancreatin.—Add one-fifth to two-fifths per cent. solution of Mall's or Merch's pancreatin to 0.3 per cent. solution of sodium carbonate. This is used to demonstrate adenoid tissue in paraffin sections. The paraffin is removed by xylol, washed thoroughly with alcohol and placed in ether in a Soxhlet apparatus for several hours to remove the fat. The sections are then brought through graded alcohols to water and placed in the digestive fluid for several hours to several days until all the cellular elements are removed. The sections may then be stained after careful washing with water with an aqueous solution of fuchsin or an aqueous solution of toluidin blue, then dehydrated, cleared and mounted.

The preparation of the framework of organs by means of trypsin digestion are too complex to be considered here.

Mall utilizes the pancreatic digestion for the differentiating *reticulum*. Frozen sections forty to eighty microns thick are placed for twenty-four hours in the following solution: Pancreatin 5 grams, bicarbonate of sodium 10 grams; water 100 c.c. Wash carefully with water. Transfer sections to a half test-tube of water and shake thoroughly. Spread the tissue carefully upon a slide to dry. Next allow a few drops of the following stain to dry upon the preparation: Picric acid 10 grams, absolute alcohol 33 c.c., water 300 c.c. Stain for one-half hour in the following: Acid fuchsin 10 grams; absolute alcohol 33 c.c., water 66 c.c. Wash a moment with a picric acid solution, dehydrate, clear with xylol and mount in balsam.

Bleaching.—At times it is desirable to bleach tissues or remove pigments and for this certain *bleaching solutions* are used.

Mayer's Chlorine Method.—To a few crystals of potassium chlorate in a test-tube, add two or three drops of strong hydrochloric acid. As soon as chlorine gas is evolved add a few cubic centimeters of fifty per cent. or seventy per cent. alcohol. The tissue, previously soaked in alcohol, is now dropped into the above solution and allowed to remain fifteen minutes to two hours. Sections or slides may be treated in the same way. Oxygen may evolve by using nitric acid in place of hydrochloric acid, but the action is the same. This method is adaptable for the removal of pigment from skin or eyes of Arthropods or for bleaching tissues previously blackened in osmic acid.

Peroxide of Hydrogen (Pouchet's).—The tissue is placed in a watch glass of glycerin and five to six drops of hydrogen peroxide are added. The process must be carefully watched as prolonged action of the reagent causes maceration. This reagent removes pigment and bleaches osmic and chromic materials.

Sulphurous Acid (Gilson).—A few drops of a solution of sulphurous anhydride (SO_2) in alcohol very quickly bleaches tissues discolored by bichromate solutions.

Preparation of Sections for Microscopic Study.—In order to study sections under the microscope the tissues may be frozen and sectioned or imbedded in paraffin or celloidin and then sectioned.

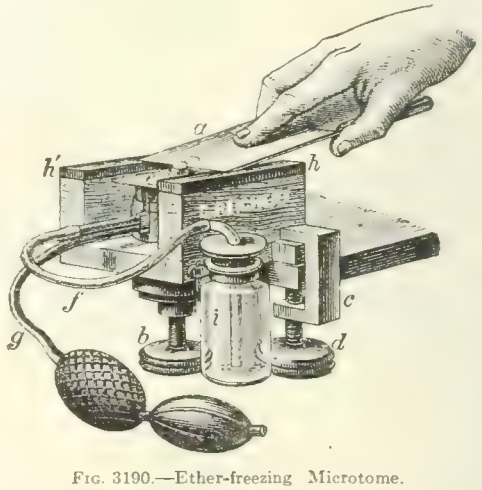

Fig. 3190.—Ether-freezing Microtome.

Freezing Method.—For this method a special *freezing microtome* is required. The *congelation* is produced by ether, rhigolene or compressed carbon dioxide. The ether freezing microtome is shown in Fig. 3190.

The specimen to be frozen is placed on the metal plate *e*, and is frozen by a spray of ether delivered on

the under side of the plate by the spray tubes passing through its side. The ether is placed in the bottle *i*. The air is compressed by the double bulbs and conveyed to the spray tubes through the tube *g*; the ether through the tube *f*. The knife *a* is broad and has a chisel edge; it slides on the glassways *h'h*. The block of tissue is raised and lowered by the micrometer screw *b*.

For cutting sections frozen with CO_2, the microtome and cylinder in Figs. 3191 and 3192 are the latest types.

Fig. 3191.—Automatic Freezing Microtome. (Spencer.)

The piece of tissue is placed upon the hard rubber freezing chamber that has been moistened with a little water. The cylinder that has been fastened to a table is provided with an outlet tube and a valve; when the tissue is placed in position, the valve is gradually opened, permitting the CO_2 to enter the freezing chamber, and the freezing process is begun. Freezing should be carried on cautiously. The specimen may be frozen in the microtome and as soon as solid may be immediately cut. The automatic feed microtome may be set to cut any desired thickness. The specimen advances automatically. The knife is so mounted that by moving the lever handle the knife describes a flattened circle corresponding to the double movement in freehand sectioning. By this manner of holding the knife by arms which are not parallel, the entire cutting edge of the knife is utilized, insuring uniform wear and permitting the cutting of very large sections. This peculiar swinging cut is especially adapted to frozen-section cutting.

Fig. 3192.—Carbon-dioxide Cylinder and Freezing Chamber.

A portable freezing microtome consisting of a freezing microtome and tank mounted upon a roller-stand is now made by Sartorius. This can be taken into the operating room, sections made and diagnosis given while the operation proceeds.

In freezing tissues, care should be taken that congelation goes on slowly and sections should be cut at about four microns, if possible. For rapid diagnosis the tissues are neither fixed nor infiltrated, but Arthur Bolles Lee does not recommend this plain method as he finds that the formation of ice crystals frequently causes the tearing of the delicate elements. If no infiltration mass is utilized, the procedure is as follows:

Wright's Method.—1. Place the fresh specimen in ten per cent. solution of formalin for about two hours. If time does not allow of this, boil the specimen in the same strength of formalin for two to three minutes. The histological details are not so good after boiling.

2. Rinse in water.

3. Cut sections with a freezing microtome. The sections should be thin.

4. Float the section on a slide, smooth out, and remove the surplus water.

5. Place a sheet of smooth cigarette paper on the section, and press this and the section down with a pad of soft, smooth filter paper, the face of which has been moistened with a few drops of ninety-five per cent. alcohol. Remove the filter paper and carefully strip off the cigarette paper, leaving the section adhering to the slide.

6. Flood the section, adhering to the slide, with absolute alcohol; after about thirty seconds drain off the alcohol.

7. Flow over the section and the adjacent surface of the slide a *thin* solution of celloidin; drain off immediately.

8. Flood the slide with ninety-five per cent. alcohol, and immediately place the slide for ten seconds in water. This hardens the celloidin film and prevents the section from curling.

9. Stain with hematoxylin or any combination of stains.

10. Dehydrate in ninety-seven per cent alcohol.

11. Clear in oil of origanum, and mount in balsam.

A More Rapid Method is as Follows: Freeze the tissues, with or without preliminary hardening in formalin, and cut sections. Transfer the sections to water and draw upon a clean slide. Drain off the water and dry over a small alcohol lamp.

Cover with hematoxylin for two minutes, drain and cover with a fifty per cent. solution of lithium carbonate for one minute (to deepen the stain). Stain with Van Gieson's stain for one minute, wash with water, then dehydrate with ninety-five per cent. and then absolute alcohol, clear with xylol and mount in balsam. The section may be examined while it is clearing. With this method a diagnosis can be given within a very short time.

Mallory (1913) of Boston makes frozen sections, transfers them to a slide, places on methylene blue stain, covers with a glass and while the section is staining, makes his diagnosis. The whole operation requires only a few minutes, but is successful only in the hands of an expert.

Cut frozen sections are difficult to handle.

Olt recommends that they be placed in a one per cent. solution of gelatin, places them upon a slide and hardens for about an hour in formalin vapor; they are then transferred for a few minutes to a ten per cent. formalin and washed in water. The sections may then be stained in any manner desired and then dehydrated, cleared and mounted.

Amtschkow puts the frozen sections into fifty per cent. alcohol, transfers them to a slide prepared with Mayer's albumen, presses them down with paper, covers with ninety-eight per cent. alcohol and gradually changes to lower grades of alcohol and then to water. They are then ready to be stained, dehydrated, cleared and mounted.

It is advisable, however, to use some infiltrating mass and gum mucilage and syrup are the best.

Cole's method is as follows: Dissolve four ounces of gum acacia in six ounces of distilled water. Dissolve one pound of loaf sugar in one pint of water and boil. Mix five parts of gum mucilage and three parts of syrup for ordinary tissues. For nerve tissues, retina and easily separable tissues, use four parts of syrup to five of gum. Add five grains of carbolic acid crystals to each ounce of the medium.

Soak the pieces of tissue for several hours in the mixture. Wipe the mixture from the surface of the tissue

with a cloth; cement the tissue to the freezing plate with a little gum mucilage, just after starting the spray, at the same time surrounding the tissue block with gum mucilage. This combination prevents the curling of the sections as well as the splintering that occurs, ordinarily, when they are frozen too hard.

The sections are then transferred to slides, stained, dehydrated, cleared and mounted.

Infiltration Methods.—In the preparation of the tissues by the *paraffin* or *celloidin methods*, the following steps are required: (1) Fixation, (2) dehydration, (3) clearing, (4) infiltration, (5) blocking.

1. *Fixation* is the process by which the tissue elements are coagulated through the use of solutions or gases, thereby keeping them as nearly in the normal state as possible. It implies a rapid *killing* of the elements so that they cannot alter their form, also a hardening that prevents the succeeding agents from producing an alteration. In order to be a desirable reagent, a fixative must act rapidly and in such a way as not to interfere with the action of the succeeding agents used and it must not interfere with the actions of the stains. Chromium salts, osmic acid and platinic chloride interfere with stains, and must be thoroughly removed; alcohol, formalin, acetic acid, corrosive sublimate, picric and nitric acids are either neutral or favorable to stains.

The majority of the fixatives enter into a chemical combination with the protoplasm of the tissue elements and when solutions of chromium salts and salts of heavy metals are used these chemical compounds are mostly insoluble, a desirable property. Although rapidity of action is a desirable quality of fixing agents, yet it is not an absolutely essential one, for some of the best fixing agents for nerve tissues act very slowly. The interrelation between fixing and staining is shown by the fact that certain stains give very poor or no results with certain agents, while with others they leave nothing to be desired. Some fixing agents besides acting as such, act as *mordants*, that is, they combine with certain coloring matters in such a way as to afford important stains that cannot be produced in any other way. Swelling or shrinking of the cells and intercellular substance must not occur.

Besides killing and hardening, fixatives change, the refractive indices of the various tissue elements raising them in variable degrees, causing an *optical differentiation*. This is a desirable property for by this measure various parts are contrasted in a way that does not exist in the living tissues. On the other hand, such fixatives interfere with the ordinary stains as carmine and like colors unless the fixative has first been removed.

After treating with a fixing agent, it is necessary to wash the tissue in running water or alcohol to remove the excess or the subsequent steps would be interfered with. Such a step is necessary after the use of chromic acid or its salts or osmic acid while picric acid requires alcohol; formalin and corrosive sublimate require no such after-treatment. Both fixation and washing are facilitated by gentle heat, not over 40° C.

To insure successful fixation, the tissues must be fresh and show no postmortem changes. Most tissues are good until twenty-four hours after death if the body has been kept cool, but special stains of nerve tissues are not successful usually unless the tissues are removed very soon after death. In addition, large quantities of the fixative should be employed and if this agent should become cloudy before the required time, it should immediately be changed. The washing should also be carried on with large quantities of the proper liquid.

Whole organs may be fixed by washing out the vessels with normal salt solution and irrigating them, through the vessels, with the fixative for several hours. They are then placed in a large quantity of fixative for several days or longer. Large animals as chimpanzees and goats have been fixed in this way by Kolmer.

Narcotization.—Animals that would contract suddenly by placing in a fixing agent are best *narcotized* first. This may be done by introducing small quantities of an *anesthetic* into the water and waiting until the desired effect has been produced. They may then be fixed.

Nicotine (*Andres*) may be employed for marine forms by mixing one gram with a liter of sea water and adding this to the sea water containing the animals by means of a thread. This transfers the liter of narcotizing fluid in about twenty-four hours.

Chloroform is recommended by Preyer for starfishes.

Cocaine or *eucaine* (one per cent.) and *chloroform* (saturated solution in sea water or fresh water) is recommended by Waddington.

Bianco recommends a solution containing glycerin 20 part, seventy per cent. alcohol 40 parts, sea water 40 parts. This is poured carefully upon the surface of the sea water and allowed to diffuse slowly through it; it requires several hours to act.

Sulima (1909) recommends a mixture of 99 parts sea water and 1 part of a ten per cent. solution of chloretone in absolute alcohol for invertebrates (Scyllium and Anguilla).

To get complete fixation, most reagents must have an acid reaction. This is gotten by adding acetic acid (one to five per cent.) and this not only gives the desired reaction, but assists the penetration of the fixative and also assists markedly in the optical differentiation of the various elements of the tissues. From this it will be seen that the best fixing agents contain two or more active agents.

In order to insure *proper fixation, the pieces of tissue should not be large, i.e.* one-quarter to one-half inch cubes. If larger sections are desired, the organ may be cut into slices about one-eighth of an inch thick and nicked across the face at intervals of about one-half of an inch. Some fixatives act very rapidly and others slowly. Some cause slight swelling and others have a tendency to cause a slight shrinkage. In order to avoid such results these agents are combined in various ways, thus insuring satisfactory results. The time required for the various fixatives and special after-treatment, if any, will be mentioned in connection with each.

Bichloride of mercury is probably one of the most commonly used salts for fixation. It acts rapidly and has the advantage of interfering with very few stains and in fact is essential for the success of certain stains.

Heidenhain's Solution.—Add 112 grams of bichloride of mercury to a hot 0.5 per cent. solution of sodium chloride. Upon cooling the excess of bichloride will crystallize and maintain a saturation. The sodium chloride assists the penetration of the bichloride. Half-inch cubes require three to four hours for fixation.

Arthur Bolles Lee (1913) recommends that the bichloride be dissolved to saturation in a one to five per cent. glacial acetic acid solution, while Van Beneden recommends a twenty-five per cent. acetic acid solution.

Ohlmacher's solution consists of absolute alcohol 80 parts, chloroform 15 parts, glacial acetic acid 5 parts and bichloride to saturation. This is said to fix ordinary pieces of tissue in fifteen to thirty minutes.

Stoelzner recommends a saturated solution of bichloride in a four and one-half per cent. sugar solution as isotonic for warm-blooded animals.

Held prefers fixing nerve tissue in a one per cent. solution of sublimate in forty per cent. acetone. After fixation, the excess bichloride is washed out by carrying the tissue through increasingly concentrated grades of aceton.

Gilson's mixture consists of nitric acid (1.456 sp. gr.) 15 c.c., glacial acetic acid 4 c.c., bichloride 20

grams, 60 per cent. alcohol 100 c.c., distilled water 800 c.c. This solution acts rapidly and the tissue should be washed in alcohol.

Petrunkewitsch recommends the following: Water 300 c.c.; absolute alcohol 200 c.c.; glacial acetic acid 90 c.c.; nitric acid 10 c.c.; corrosive sublimate to saturation.

After fixation in a fluid containing bichloride of mercury, it has been recommended that the tissue be thoroughly washed in water or better 70 per cent. alcohol containing tincture of iodine to remove the excess fixative. The bichloride renders the tissues brittle and will not stain well and the effect is sure to be the same if these tissues remain too long in alcohol. Heidenhain prefers to use sodium thiosulphate to remove the bichloride. Mann and others prefer to remove the bichloride after the tissue has been sectioned (see Slide Technique). Lee considers it a good fixative for general work, but says it is not to be trusted for cytological work.

Carnoy and Lebrun.—Absolute alcohol 1 volume, glacial acetic acid 1 volume, chloroform 1 volume, bichloride to saturation. This mixture should be prepared just before use as it does not keep long. This is especially useful in fixation of ascaris ova.

Isolated ova are fixed in fifteen to thirty seconds and those in the uterus in about ten minutes. Lee recommends it as one of the most rapidly acting fixatives. All traces of acetic acid must be washed out with alcohol.

Potassium Bichromate.—This salt as a three and one-half per cent. aqueous solution is a good fixative and hardener. Its strength is gradually increased one-half to one per cent. by frequent renewals up to six per cent. in the course of six weeks. Tissue may be left longer without injury. It acts slowly so is often combined as shown in the following solutions. The bichromate should be thoroughly washed out with water after fixation and during dehydration the tissues should be kept in the dark. The bichromate may be bleached out before staining if desired.

Mueller's Fluid.—Potassium bichromate 60 grams, sodium sulphate 30 grams, distilled water 1,000 c.c. Lee states that the solution by itself is not as satisfactory as formerly believed.

Tellyniczky's Fluid.—To a three and one-half per cent. solution of potassium bichromate add five per cent. of glacial acetic acid. The acetic acid aids the penetration and hastens the action of the bichromate, so that tissues are fixed in twelve to twenty-four hours. They should be thoroughly washed in water before dehydration. The nuclei are very well preserved by this solution.

Zenker's Fluid.—This consists of Mueller's fluid (see above) 1,000 c.c., corrosive sublimate 112 grams; mix and add to the solution just before use, five per cent. of glacial acetic acid. This requires twelve to twenty-four hours to act and should be freshly prepared before use. Spuler recommends that the fixation be completed in Mueller's fluid.

Helly leaves out the acetic acid and substitutes five per cent. of formalin, just before use.

Maximow's solution (1909) is probably the best modification of Zenker's. In place of the acetic acid, he uses ten per cent. of formalin and at times a ten per cent. of a two per cent. solution of osmic acid. Fixation should be carried on in the dark, if osmic acid is used.

Bensley takes equal parts of a saturated alcoholic (ninety-six per cent.) solution of bichloride and two per cent. aqueous solution of potassium bichromate.

Erlicki's Solution.—Potassium bichromate 2.5 grams; copper sulphate 1 gram, distilled water 100 c.c. This agent requires about ten days at ordinary room temperature (whole spinal cord) or four days in an incubator. Precipitates may form in the tissues and these can be removed by washing with hot water or with water slightly acidulated with hydrochloric acid, or by treating the tissues before dehydration with a 0.5 per cent. solution of chromic acid.

Dekhuyzen's Fluid.—Bichromate of potassium (2.5 per cent. solution in sea water) 250 c.c.; nitric acid (6.3 per cent.) 25 c.c., osmic acid solution (2 per cent.) 54 c.c. This solution is especially adapted for marine animals.

Ammonium Bichromate.—This salt acts more rapidy and hardens more slowly than potassium bichromate. It is usually used as a five per cent. solution.

Osmic Acid.—This is really the tetraoxide of osmium and is not a true acid. It is a very volatile substance and readily reduces if dust enters the solution. Light alone will not effect the reduction. It is usually kept in stock as a two per cent. solution and Lee recommends that the two per cent. solutions be made up in one per cent. chromic acid solution, as it does not then readily reduce. Cori recommends that a sufficient quantity of permanganate of potassium be added to an aqueous solution of osmic acid so as to impart a slight rosy tint; the solution will not reduce. This solution will gradually become colorless and should then become tinted again. Osmic acid fixes the cytoplasm very well, but the nuclei but poorly.

Fixation by vapor is to be employed only when the pieces of tissue are thin or small. The specimen is fastened to a cork and the cork then fitted into a wide-mouthed bottle that contains a one per cent. solution of osmic acid or some of the solid. Cells may be placed on a slide and inverted over the vapor and when they become brown (thirty to sixty seconds) they are fixed. They may then be slightly washed with water and stained with methyl green if the specimens are to be preserved in water, otherwise they are to be stained with hematoxylin, picrocarmine or alum carmine thereby giving permanent preparations. Larger specimens like retina, will require several hours for fixation. As osmic acid does not fix nuclei very well, Gilson recommends vapor of a freshly prepared solution of osmic and acetic or formic acids. The vapor penetrates more rapidly and more deeply than the solution. In solution osmic acid is seldom used alone as a fixing agent and then with strength varying from 0.05 to 0.5 per cent. Pieces of tissue should be as small as possible and fixed in the dark. When brown throughout the tissues are fixed. The action is aided by the addition of glacial acetic acid to the amount of five per cent. Tissues must be well washed after fixation and if overstained, may be bleached as above. *Osmic acid is a stain for fat.*

Chromic acid is usually used as an aqueous solution of one-tenth per cent. and one per cent. strength for ova and weaker, one-fiftieth to one-eighth per cent., for nerve tissues; it is allowed to act for one to several hours. It may, however, be used for several days to a week in fixing mucous membranes. Large quantities of the fixative are required and it should be changed frequently if the longer periods are employed and a weak solution should be employed first. For quarter-inch cubes, fixation will require several weeks and the solution must be changed frequently. As it is not a very penetrating agent it is not often used alone. It may be kept in stock in a ten per cent. solution and diluted when required.

After fixation in chromic acid, the tissues should be thoroughly washed for several hours, preferably in running water. They are then transferred to fifty per cent. alcohol for six to twenty-four hours, seventy per cent. six to twenty-four hours and then to eighty per cent. until required. The treatment in alcohol should be carried on in the dark and the alcohol changed as long as it becomes yellow. Precipitates do not readily form if the treatment is carried on with the exclusion of light. Mayer recommends that the tissues be rinsed in water and transferred to seventy per cent. alcohol and kept in the dark and changed until the alcohol remains colorless. It may then be further dehydrated, cleared, infiltrated, and blocked. The

chrome compounds may be removed from the sections by placing them in acid alcohol (seventy per cent. alcohol with one per cent. strong hydrochloric acid) until bleached. After washing the sections may be stained with any of the ordinary stains.

Chromoformic Acid (Rabl).—Add four or five drops of formic acid to 200 c.c. of a one-third per cent. solution of chromic acid and allow tissues to remain for twelve to twenty-four hours. Wash with water and carry through in the usual manner. This is recommended for the study of karyokinetic figures.

The combinations of chromic and osmic acids are more satisfactory than their plain solutions.

Flemming's Solution.—The "weak solution" consists of chromic acid 0.25 gram; osmic acid 1 gram; glacial acetic 1 c.c.; water 100 c.c. The acetic acid should be added just before use. Meves recommends that one per cent. of sodium chloride be added.

The "strong solution" consists of one per cent. chromic acid solution 15 parts, two per cent. solution of osmic acid 4 parts, glacial acetic acid 1 part. The weaker solution is used for small objects. The stronger solution has better penetrating powers and fixes in a few hours or one to two days. If the stronger solution be used, it requires only four times the bulk of the object. Tissues should be washed for twenty-four hours in running water.

Fol's Modification.—One per cent. chromic acid 25 parts; one per cent. osmic acid 2 parts, two per cent. acetic acid 5 parts, distilled water 68 parts.

Meves' Modification.—One-half per cent. chromic acid 15 parts, two per cent. osmic acid 2 to 4 parts, acetic acid 1 part. This is recommended for delicate objects and is said to cause less shrinkage than the foregoing solutions.

Johnson's Mixture.—Two and one-half per cent. potassium bichromate 76 parts, two per cent. osmic acid 10 parts, one per cent. platinic chloride 15 parts, glacial acetic or formic acid 5 parts. The last reagent is to be added just before use.

Hermann's Solution.—One per cent. platinic chloride 15 parts, two per cent. osmic acid 2 to 4 parts, glacial acetic acid one part. This is better for protoplasmic fixation than the chromic acid mixture. Both Flemming's and Hermann's solutions act the same in that they mordant the chromatin so that it responds better to the basic stains, especially the coal-tar dyes. The platinum of Hermann's solution makes it difficult to use the protoplasmic stains.

Borrel's Mixture.—Osmic acid 2 parts, chromic acid 3 parts, platinic chloride 2 parts, glacial acetic acid 20 parts, distilled water 350 parts.

Zacharias' Solution.—Glacial acetic acid 1 part, absolute alcohol 4 parts, two per cent. osmic acid solution a few drops. This mixture is especially recommended for the fixation of ova of Ascaris requiring but a short time for fixation. *Lee* found it useful for other objects. The fixative should be washed out with alcohol and aqueous solution avoided as much as possible. Both nuclei and cytoplasm are well preserved and any stain may be employed.

Marchi's Fluid.—Mueller's fluid 2 parts, one per cent. osmic acid 1 part. Small pieces of tissue are fixed from five to eight days, washed thoroughly in running water and hardened in alcohol. This solution is used especially in the study of degenerated myelin sheaths.

Pianese's Solution.—One per cent. solution of chloride of platinum and sodium 15 c.c., one-fourth per cent. chromic acid 5 c.c., two per cent. osmic acid 5 c.c. formic acid 1 drop. Small pieces of tissue, not over two millimeters thick, are fixed in thirty-six hours. Wash thoroughly in running water and transfer to eighty per cent. alcohol. Sections are to be stained by Pianese's special method. This fixative is especially recommended for karyokinetic figures and so-called *cancer bodies*.

Palladium Chloride.—Employed by Waldeyer in one-thousandth per cent. aqueous solution, with the addition of a few drops of hydrochloric acid to aid in the solution, for softening the cochlea. The specimen is placed in this solution for twenty-four hours, and then in absolute alcohol for the same length of time.

F. E. Schulze uses this salt in 0.01 to 0.2 per cent. solutions. As the penetrating power is slight, small pieces of tissue are to be used—a piece the size of a bean to 30 c.c. of the solution. The hardening is completed at the end of thirty-six to forty-eight hours, but the specimen may remain in the fluid for months without harm. This solution stains protoplasm dark yellow, striated muscle brownish yellow, smooth muscle straw yellow, medullated nerves black. Hyaline membranes and elastic fibers stain slight yellow and remain transparent. Interstitial substance of connective tissue remains colorless, and will stain deeply with carmine and other stains, while the tissue colored by the palladium remains unstained. Sections are to be well washed in water and mounted in glycerin.

Fraenkel recommends the following as a fixative for connective tissue: Palladium chloride, one per cent. aqueous solution, 15 parts, two per cent. solution of osmic acid 5 parts, and a few drops of acetic acid.

It should be borne in mind that tissues fixed in osmic acid or chromic acid solutions must be thoroughly washed in running water and dehydrated in the dark until the alcohol is colorless and that overcoloring may be remedied by bleaching.

Alcohol.—For the study of certain cell contents, as glycogen, tissues must be fixed in *absolute alcohol* and the use of aqueous reagents and stains avoided as much as possible.

Alcohol of ninety-five per cent. strength may also be used as a fixative, but Mallory and Wright state that the superficial parts of the tissue are shrunken and are extremely hard. They recommend that the tissue be placed for two to four hours in eighty per cent. alcohol and then transferred to ninety-five per cent. alcohol for twelve to twenty-four hours. The shrinkage is less. The tissues are then transferred to eighty per cent. alcohol for preservation or, better, immediately carried through clearing and imbedding.

Alcohol of seventy per cent. strength has been found useful by the writer in fixation of small fetuses when collecting at an abattoir. At times it is necessary to leave a container for several days and the reagent gives good results.

Formalin, Formaldehyde, Formol.—This reagent is a saturated solution of formaldehyde gas in water (thirty-eight to forty per cent.). The solution should be kept in a cool place in dark bottles and decomposition is likely to occur. Glycerin is said to prevent this. The solutions are acid in reaction, and if undesirable as such, they may be carefully neutralized. Formaldehyde gas is very irritating to the mucous membranes and, in susceptible individuals, may cause serious inflammations. Its effect upon the skin is irritating, rendering it harsh and rough for several days, and in the constant handling of specimens preserved in it the skin may crack. Such cracks heal with difficulty. As formalin is so extensively used in the preservation and fixation of gross specimens it is necessary to use rubber gloves in handling them on account of the above effects. For *gross specimens*, the strength of the solution should be about one to two per cent. and it should be renewed at the end of twenty-four hours and thereafter if necessary.

Preservation of Gross Specimens.—For such purpose, it is usually used in the form of *Kaiserling's solution No.* 1. This consists of formalin 200 c.c., potassium nitrate 5 grams, potassium acetate 30 grams, water 1,000 c.c. As this solution bleaches somewhat the gross specimens are transferred to eighty-five per cent. alcohol until the color returns, and then quickly placed in *Kaiserling's solution No.* 2, and then either preserved therein or in a special gelatin mixture. Kaiserling No. 2 consists of potassium acetate 200 grams, glycerin 400 c.c. and water 2,000 c.c. This should

be filtered and changed several times before the organs are finally mounted in it.

Formalin kills and penetrates rapidly, but it is not successful in all tissues, hence it is usually combined with other solutions. It is a powerful reducing agent and is considered incompatible with chromic or osmic acid reagents. It is never to be used in full strength, but diluted.

Lee recommended it in a four per cent. solution, *i.e.* 1 part formalin and 9 of water. This is really a *ten per cent. solution of the usual solution purchased.* Fixation is usually accomplished in twelve to twenty-four hours and then seventy per cent. alcohol for the same time and preserved in eighty per cent. alcohol.

Lavdowsky recommends formalin 6 parts, ninety-five per cent. alcohol 20 parts, glacial acetic acid 1 part, water 40 parts, or formalin 5 parts, alcohol 15 parts, acetic acid 1 part, water 40 parts.

Gulland uses formalin 1 part, alcohol 9 parts, for blood. This is an excellent fixative for this purpose.

Bles recommends formalin 1 part, seventy per cent. alcohol 90 parts, glacial acetic acid 3 parts.

P. Bouin recommends saturated aqueous solution of picric acid 75 parts, formalin 25 parts, acetic acid 5 parts; this solution requires twelve to eighteen hours and fixation is complete and satisfactory and admits of general and special staining methods.

Picroplatinic formalin (*M. and P. Bouin*) consists of one per cent. platinic chloride 20 parts, saturated solution of picric acid 20 parts, formalin 10 parts, formic or acetic acid 5 parts. This solution is excellent, but keeps only a few days.

Formalin-Mueller (*Orth's fluid*) consists of Mueller's fluid 10 parts, formalin 1 part. It should be prepared fresh. Fixation at room temperature requires twelve hours. If carried on in an incubator three hours are sufficient. Tissues should be washed thoroughly in running water. It is especially of use in the fixation of nerve tissues.

Mueller takes formalin 1 part, three per cent. bichromate of potassium 4 parts, for the intestine of mammals.

Held (1909) recommends a mixture of a three per cent. solution of potassium bichromate 9 parts, formalin 10 parts, acetic acid five per cent. for the internal ear.

Marchoux (1910) takes one per cent. chromic acid 11 parts, acetic acid 1 part, water 4 parts, formalin (just before using) 16 parts.

Picric acid when used alone is employed as a saturated aqueous solution. This consists of about 1 part of picric acid in 86 of water at 15° C. It penetrates rapidly, requires from a few seconds to twenty-four hours depending upon the size of the objects to be fixed. Infusoria are fixed in a few minutes. Picric acid should always be washed out with alcohol, preferably seventy per cent., at about 40° C. and the stains used should be alcoholic. Extraction of picric acid is more rapid if a little lithium carbonate be added to the alcohol. Objects fixed in picric acid admit readily of staining in bulk or in sections.

Picric Alcohol (*Gage*).—Picric acid 1 part, ninety-five per cent. alcohol 250 parts, water 250 parts. Fix for two to three days and wash out with seventy per cent. alcohol.

Picroacetic Acid (*Lee*).—Saturated solution of picric acid and one per cent. of acetic acid.

Zimmer's Mixture (1909).—Saturated solution of picric acid 15 parts, absolute alcohol 9 parts, acetic acid 1 part.

Picrosulphuric Acid (*Kleinenberg's Solution*).—To 200 c.c. of a saturated aqueous solution of picric acid add 4 c.c. of concentrated sulphuric acid. Allow the precipitate to settle and then filter. Dilute the filtrate with 600 c.c. of water and filter if necessary after twenty-four hours. Tissues and young embryos are fixed in one to twenty-four hours. Transfer to seventy per cent. alcohol until bleached.

Picronitric Acid (*Mayer*).—Nitric acid (twenty-five per cent. N_2O_5) 5 volumes, water 100 volumes, picric acid to saturation. This acts like the preceding, but is harder to wash out. Lee considers it better than the picrosulphuric solution.

Rawitz recommends picronitric acid 1 part, one per cent. chromic acid 4 parts. Wash out with seventy per cent. alcohol.

A *second mixture* of Rawitz is as follows: Picronitric 6 volumes, two per cent. osmic acid 1 volume. Fix for one-half to three hours and place in seventy per cent. alcohol.

Picrosublimate (*Rabl*).—Saturated aqueous solution of sublimate 1 part, saturated picric acid 1 part, distilled water 2 parts. Embryos are fixed in twelve hours and then should be washed for two hours and transferred to weak alcohol.

Pacaut takes 200 parts of a saturated solution of sublimate and picric acid, 6 parts of a three per cent. solution of platinic chloride and 5 parts of a sixteen and one-half per cent. solution of chromic acid.

Lenhossek (1907).—Saturated solution of sublimate 75 c.c., acetic acid 5 c.c., fifty per cent. alcohol 25 c.c., picric acid to saturation.

Chloride and Acetate of Copper (*Ripart and Petit's Liquid*).—Camphor water (not sat.) 75 grams, distilled water 75 grams, crystallized acetic acid 1 gram, acetate of copper 0.3 gram, chloride of copper 0.3 gram. This is a very delicate and moderate fixative according to Lee. Objects thus fixed stain instantly with methyl green. Osmic acid increases its fixative powers. Excellent for cytologic study.

Acetone is used by Scholz (1905). Small objects are fixed in warm acetone in one-half hour to one hour. They are then to be carried through alcohol-ether mixture and then into celloidin.

Fuss (1906) recommends its use cold.

Lintwarew (1911) used it for the fixation of red blood cells as it preserves the hemoglobin.

Bing and *Ellermann* recommend the addition of one per cent. formalin for the fixation of medullated nerve fibers.

Dehydration.—After the tissue has been fixed, it is then ready for the next step or that of dehydration. This process has for its object the removal of all the water, preparing the tissue for the next step or that of clearing. As clearing is usually carried on by an agent that is not miscible with water, it is necessary to remove the latter completely. Tissues fixed in acetone do not require these steps as acetone is miscible with alcohol-ether or celloidin. This is accomplished by means of *ascending strengths of alcohol.* If an aqueous fixative has been used, the tissues are placed in fifty per cent., alcohol for six to twenty-four hours then into a seventy per cent., six to twenty-four hours, and then eighty per cent. for twenty-four hours. If it is undesirable to carry them through clearing and the following steps, they may be preserved for an almost indefinite time in eighty per cent. alcohol.

Tissues fixed in chromic compounds should be dehydrated in the dark. For those fixed in sublimate solutions, the following treatment is recommended. After washing with water and dehydrated to the seventy per cent. strength, they should be treated with seventy per cent. alcohol containing sufficient tincture of iodine to impart a port wine color. They are allowed to remain here until they are the color of the solution and by that time all the bichloride precipitated in the tissue will have been removed. In obstinate cases, Mayer recommends the following solution: Potassium iodide 5 grams, distilled water 5 c.c. Dissolve and mix with a solution of 0.5 iodine in 90 c.c. of ninety per cent. alcohol. This solution is to be added to the seventy per cent. alcohol containing the tissues in sufficient quantities to bleach the tissues. Others prefer to remove the bichloride from the tissues when sectioned.

If it is desired to infiltrate the tissues, they are trans-

ferred to ninety-five per cent. alcohol for twenty-four hours. This should be renewed once or twice if many pieces of tissue are being carried through. They may then be placed in absolute alcohol for twelve to twenty-four hours, after which they are ready for the next step.

Clearing.—*Clearing* or *dealcoholization* is necessary for paraffin infiltration as alcohol and paraffin are incompatible. The choice of reagent differs according to whether paraffin or celloidin is to be used for infiltration.

Paraffin Method.—For the paraffin method chloroform or an oil or oil-like substance is required. Chloroform is employed if the infiltration is to be carried out in the cold, that is with tissues that cannot stand heat for an extended period. The retina or whole eyeball, for example, is transferred from alcohol to pure chloroform where it is allowed to remain until permeated with chloroform. This requires from one or two to eight hours. The object at first floats and when it becomes submerged, the process is completed. It is then ready for infiltration. (See *Cold Method.*)

For ordinary paraffin infiltration, oils are used for clearing. The cedar oil method is the best.

Cedar Oil Method.—The tissues are taken from the absolute alcohol and blotted with tissue paper to remove the bulk of the alcohol and then placed in *cedar oil No.* 1 for twelve to twenty-four hours. This consists of *cedar oil* and *absolute alcohol equal parts.* The objects are then transferred to *cedar oil No.* 2 for twelve to twenty-four hours or until transparent. Cedar oil No. 2 is merely pure cedar oil. By this fractional clearing the abstraction of the alcohol is gradual and less disturbance takes place in the tissues. They are then ready for infiltration.

Some prefer to place the tissues directly into pure cedar oil for twelve hours and then into fresh pure cedar oil for twenty-four hours or until transparent. This process may be carried on in an incubator or upon the paraffin bath and the time reduced nearly one-half.

Turpentine Method.—The tissues are transferred to pure turpentine, from the alcohol after blotting, and allowed to remain until transparent, usually twelve to twenty-four hours. This is an excellent reagent for students' routine work, but if left in the turpentine too long and a paraffin of high melting-point is used, the tissues are liable to become hard and will cut unsatisfactorily.

Xylol, toluol, benzol are good clearing agents in an expert's hands for general purposes, but they clear too rapidly and the same applies to them as to turpentine. Their action is rapid and they are liable to cause shrinkage. They are useful in clearing delicate objects in the following way. The uterus of Ascaris and like objects are dehydrated in absolute alcohol and when free of water are placed in a tube of fresh absolute alcohol to which a few drops of xylol, benzol or toluol has been added and mixing after each addition; by this method 2 c.c. of benzol can be added to an equal quantity of alcohol in four to six hours and no shrinkage will result. The specimens are then to be transferred to a mixture of absolute alcohol (1 part) and benzol (3 parts) for one to three hours and then to pure benzol for one to four hours for tissues one-eighth to one-fourth inch in diameter. The blocks are then placed in benzol saturated with paraffin for two to four hours and then more paraffin is added and the container transferred to a paraffin bath for one to two hours and is then cast.

Infiltration.—The object of infiltration or imbedding is to permeate the interstices and normal cavities of the tissue with a substance which when cold (*paraffin*) or fixed (*celloidin*) will solidify in these spaces and permit the section to be made without distorting the object, by supporting it on all sides. By this means only can thin sections be cut. When the imbedding mass is solid when cold and must be melted in order to permeate the tissue, as paraffin, this process is called *fusion imbedding.* If the imbedding mass is a liquid through the action of solvents and these solvents must be volatilized before the mass becomes firm enough to cut, this process is called *evaporation imbedding,* as in the celloidin method. The paraffin method is used chiefly as it is more rapid and thinner sections can be cut. *Gum* and *gelatin* are used as imbedding masses when it is desirable to avoid the use of dehydrating agents and when chemical tests are to be made.

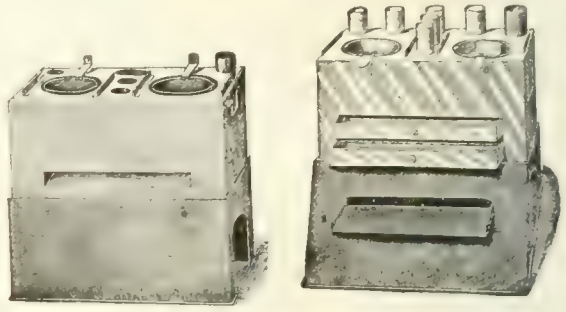

Fig. 3193.—Paraffin Water Baths

For the paraffin method, a proper *water bath* is necessary in order to maintain the paraffin at a definite temperature (Fig. 3193). More elaborate baths are shown in Figs. 3194 and 3195. Paraffin has a variable melting-point depending upon the amount of oil in it. Grades of 45° and 52° C. melting-point are the best and by properly mixing these, paraffin of any intermediate melting-point may be readily obtained. Paraffin of too low a melting-point contains too much oil and is too soft at ordinary room temperature, and must be iced before cutting in the microtome. Paraffin of too high a melting-point is unsuited for general

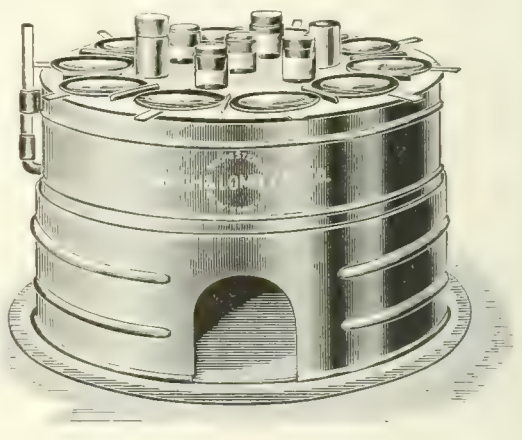

Fig. 3194.—Water Bath.

work as the higher temperatures render the tissues hard and brittle so that they will not cut readily. It is essential to maintain a bath as nearly at the melting-point as possible.

After clearing the tissues are blotted with tissue paper to remove as much of the oil as possible, but they must not be squeezed. They are then transferred to melted *paraffin No.* 1 in a paraffin bath for six to twelve hours; this removes the bulk of the oil. They are then transferred to fresh *paraffin No.* 2 for six to twenty-four hours which removes the remainder of the oil and leaves clear paraffin in the tissue. If 45° C. paraffin has been used, it is desirable to place the tissue

for a couple of hours in 52° C. paraffin and to block in this. This gives a firmer paraffin and the blocks hold up better at the ordinary room temperature and may be sectioned without preliminary cooling.

Cold, or Chloroform Method.—After the tissue has been thoroughly saturated with chloroform, it is transferred to a closed vessel containing a warm saturated solution of paraffin in chloroform and kept there for two to four hours. The tissues are then transferred to pure melted paraffin until the odor of chloroform has disappeared (two to twelve hours). It is then ready to be blocked.

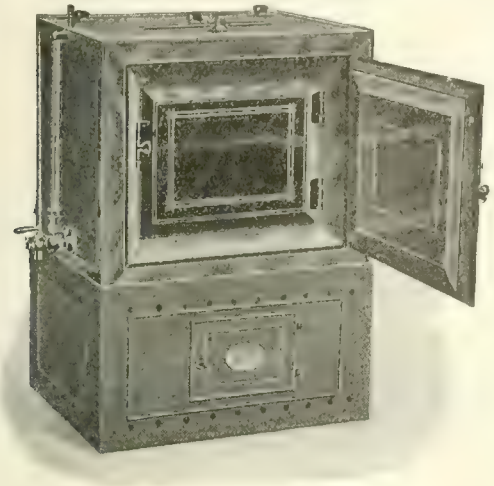

Fig. 3195.—Incubator Paraffin Bath

Mayer recommends the use of benzol for clearing, then adds small pieces of paraffin to the benzol and permits them to dissolve in the cold. After several hours the objects and benzol are transferred to an open vessel in a cold water bath and the bath gradually warmed to about 60° C. in about two hours. As fast as the benzol evaporates, melted paraffin is added. After the benzol is evaporated the paraffin is changed once and the tissue blocked. At times it is necessary to infiltrate tissues *in vacuo*. This process necessitates an air-pump, etc., but the infiltration is accomplished in a few minutes and prevents tissues from collapsing.

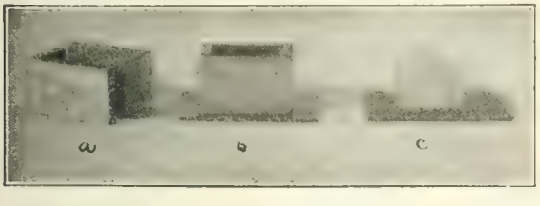

Fig. 3196.—Blocking with Leaden Angles. *a*, angles, *b*, same in place; *c*, paraffin mould.

Acetone-paraffin Infiltration.—Salkind (1913) gives the following rapid method which he prefers to the chloroform paraffin method. After fixation the tissues are to be placed in weak alcohol or transferred directly from water to a solution of two volumes of acetone, two volumes of ether and one volume of water. They remain here at least as many hours as the tissues are millimeters thick. Then place the tissues in the following solution saturated with paraffin of 36° to 40° C. melting-point, one volume acetone and one volume ether. They remain here twice as long as in the preceding mixture and are then placed in melted paraffin for five to ten minutes for each millimeter in thickness and blocked.

Blocking.—After infiltration is completed, the tissues are removed from the paraffin bath and then *blocked.* This is accomplished by the use of *leaden angles* and *brass plates*, by means of *paper boxes*, or *wooden blocks.* The leaden angles and brass plates (Fig. 3196) are cooled in ice water, dried and placed in position. A thin layer of paraffin is then poured into the enclosed space, the tissue placed therein and oriented. The mold is then filled with paraffin, and as soon as a scum is formed the whole is plunged into ice water, the angles cautiously removed, so that the ice water can act upon all sides except the bottom. This prevents the enclosure of water bubbles by the rapidly contracting paraffin. This method insures a clear paraffin. The paraffin molds are then dried and may be stuck upon wooden blocks by gently heating each and bringing them together.

If *blocks* are used, oak is preferred and the most convenient size is one and one-fourth inches long and seven-eighth of an inch square. A strip of paper is tightly wrapped around one end and sealed with paraffin so as to form a cup one-half to one inch deep. A little paraffin is run into the cup, the tissue placed therein and oriented and filled with melted paraffin and allowed to harden at the room temperature. After blocking, the specimen is then relieved of the paper and trimmed as shown in Fig. 3197, *a,b,c.*

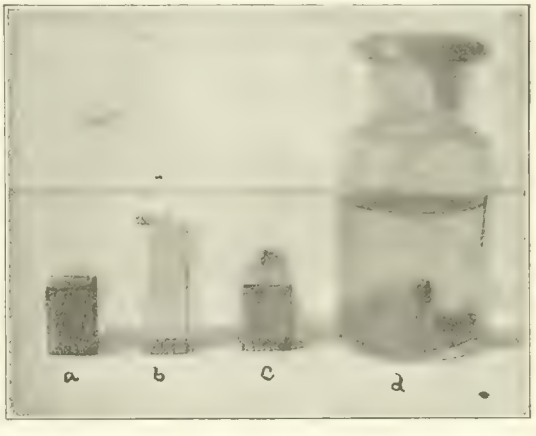

Fig. 3197.—Wooden Blocks. *a*, plain blocks, *b*, same with paper cup; *c*, trimmed paraffin block. *d*, celloidin blocks in eighty per cent alcohol.

Celloidin Infiltration.—*Celloidin, pyroxylon*, or *photoxylon* is a solid at the ordinary temperature and comes in soft shavings put up in air-tight bottles. It is soluble in alcohol and ether which mixture is also the clearing agent. This method of imbedding is of distinct advantage when large pieces of tissue are used and even whole brains are readily infiltrated and sectioned in this medium. It may be used on the most delicate tissue and specimens left in over time are uninjured. As it is transparent, it need not be removed when the section is stained and this is of advantage when delicate or detached structures are being prepared. On the other hand, this process is a rather slow one, requiring weeks and months for large blocks.

This medium is used in *two solutions, thin* and *thick.* The *thick solution* is prepared as follows: Take one ounce of dried celloidin, washing thoroughly with distilled water and then drying. By this means the powder that is usually in these packages is gotten rid of and the celloidin will be clear. If the celloidin shavings are put up moistened with water, they are washed and dried in the air upon filter paper in the same way.

The chips are then placed in a citrate bottle and covered with 150 c.c. of equal parts absolute alcohol and ether. It is advisable to soak the celloidin with absolute alcohol for a few hours and then add the ether. By this means the solution is made more quickly. The *thin solution* is made by using double the absolute alcohol and ether or diluting the thick celloidin with an equal volume of this reagent.

The tissues are transferred from the absolute alcohol of dehydration to a mixture of equal parts of absolute alcohol and ether for twenty-four to forty-eight hours and then dropped into the *thin* celloidin for one to seven days and then *thick* celloidin for two to three days to several weeks, depending upon size. Slices of whole brains require several months. When the tissues have been infiltrated with the thick celloidin, they are ready to be blocked. Paper cups are made as above, the tissues oriented and the cup filled with thick celloidin. They are exposed to the air until a scum has formed and then placed in a receptacle of eighty per cent. alcohol until the celloidin is hardened; the paper is then removed, the block trimmed and the block preserved in eighty per cent. alcohol until ready to be cut (Fig. 3197, *d*). Instead of using a thick solution, a cork-stoppered tube or slender dish may be used for infiltration and the stopper is loosed a little or the slender dish lid raised slightly so as to allow alcohol and ether to evaporate in the course of three to five days. The celloidin gradually thickens and the tissues are in this way blocked. When the celloidin mold has retracted from the sides of the dish or tube, it is then placed in eighty per cent. alcohol until hard, removed and trimmed and preserved therein until ready to be cut. To mount these molds upon blocks (clean, free from paraffin or grease), oak blocks are preferred. Dry the molds on a towel and place for a few seconds in absolute alcohol and ether mixture. Moisten the end of the block in the same and dip in thick celloidin. Next dip the celloidin block in thick celloidin and place it upon the prepared wooden block and allow it to stand in the air until the fresh celloidin is firm upon the surface and place in eighty to eighty-five per cent. alcohol.

A number of pieces of tissue may be blocked in one petri dish, filling the latter with thick celloidin and plunging in eighty to eighty-five per cent. alcohol after a skum has formed in the air. They may then be cut out in blocks when the celloidin is hard and mounted upon wooden blocks as above.

At times the celloidin does not harden sufficiently to cut readily and then the blocks should be placed in eighty to eighty-five per cent. alcohol containing one to five per cent. glycerin for twenty-four to forty-eight hours.

Celloidin may be hardened without the use of alcohol by placing in chloroform vapor or pure chloroform. If pure chloroform is used, blocks will be hardened in a few hours, but should not be allowed to remain longer than three days. Lee prefers the chloroform vapor method.

Some technicians preserve celloidin blocks in seventy per cent., while Apathy recommends that they be kept dry after dipping in melted paraffin, or, after rinsing in water, covering the blocks with glycerin jelly. The glycerin jelly can readily be removed with warm water just before cutting.

Gilson uses a mixed *celloidin and paraffin method* and clears in cedar oil before cutting. Lee has modified this method as follows: Imbed in the usual way and harden in chloroform vapor. Then place in a mixture of one part chloroform and two parts cedar oil; pure cedar oil is added from time to time until nearly pure cedar oil. When clear, the object is exposed to the air and the remaining chloroform allowed to evaporate. It may then be mounted, cut or preserved indefinitely in a stoppered bottle. Such blocks are cut dry and the cut surface will not be injured by the air under several hours.

Stepanow soaks and imbeds tissues in a solution of celloidin in equal parts of ether and clove oil, hardens in alcohol or chloroform vapor, or benzol, and cuts dry or wet.

Joliet's Gum and Glycerin Method.—The tissue is placed in a watch glass in the following mixture: a syrupy aqueous solution of gum arabic, to which six to ten drops of glycerin have been added, depending upon the weather, *i.e.* less for wet weather and winter than in dry weather or summer. Imbed and allow to dry for one to four days or to a cartilaginous consistency. Cut into blocks, turn over and allow to dry until wanted.

Gum Method.—The infiltrating medium consists of the following:

Syrup	Cane sugar	28.5	grams
	Water	30	c.c.
Gum	Gum arabic	57	grams
	Water	310	c.c.

Mix together four parts of syrup and five parts of gum; to this add nine parts of a saturated aqueous solution of boric acid. Filter through muslin.

Free the tissue from all traces of alcohol and place in the above mixture until permeated, usually twenty-four hours for one-fourth-inch cubes. A longer time is better and the process may be assisted by placing the container in a warm place.

Tissue infiltrated with gum must be frozen and cut in a freezing microtome.

Cutting Sections.—For paraffin and celloidin cutting, other microtomes are used. These vary from the comparative simple and inexpensive hand microtomes to the complicated, expensive and exact precision microtome of Minot.

Sections of Hardened Tissue.—Sections of hardened tissue may also be made by free-hand cutting. For free-hand cutting, the first requisite is a good razor or knife. An ordinary hollow-ground razor, with the lower side ground flat, will answer; but if one practises free-hand cutting to any extent, it is better to be provided with a larger and heavier one.

The section cutting is performed as follows: A shallow dish is partially filled with alcohol, with which the specimen and razor blade are to be constantly flooded, the blade being dipped into the alcohol. The specimen is held firmly between the fingers and thumb of the

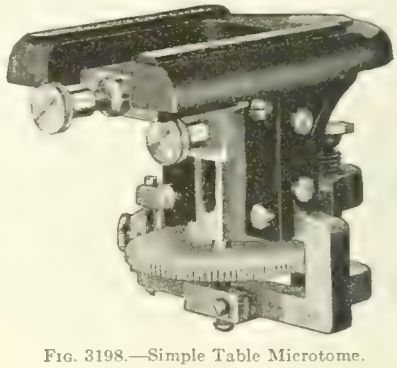

Fig. 3198.—Simple Table Microtome.

left hand, and the razor lightly with the right, the handle resting on the fingers, the thumb being used for changing the direction of the edge of the razor. The section is cut by drawing the razor blade diagonally through the specimen, from heel to point, and then floated off into a dish of alcohol. After cutting every third or fourth section the razor should be stropped, so as to keep the edge in the best possible condition.

Microtomes.—A *simple* and rather inexpensive microtome is shown in (Fig. 3198). This is a hand-feed table microtome and will cut sections five microns in thickness. It has also the advantage of being adjusted to frozen section work and routine laboratory

work where the highest degrees of accuracy are not required.

A more accurate microtome is shown in Fig. 3199. This is an automatic feed and is adapted for celloidin or paraffin cutting. The object remains stationary while cutting as it is held by a rigid clamp that is adjusted in one plane and vertically. The knife is carried upon a wedge-shaped block that slides in ground ways. The longer bed gives a greater freedom of motion and permits of cutting larger objects imbedded in celloidin than the preceding form. The feed-screw is operated by the motion of the knife block transmitted through an arm extendng from the block. The microtome may also be operated as hand feed. The object clamp is reversible and may be brought to the right of its slide bed. The feed mechanism is controlled by an adjustable cam, giving a feed of two to thirty microns in increments or two microns. CO_2 freezer and ether freezing attachments can readily be fitted.

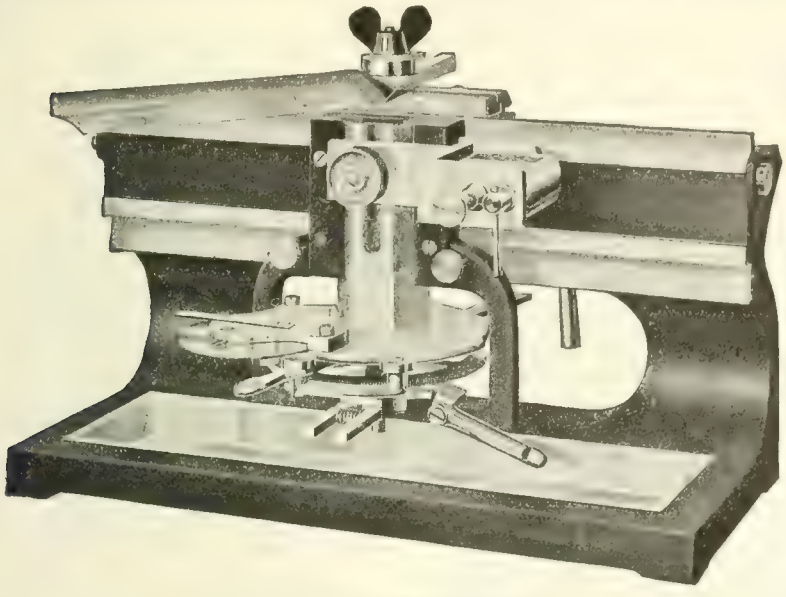

Fig. 3199.—Automatic Microtome.

Fig. 3200 is the *latest rotary microtome* designed by Prof. Minot of Harvard. It is a marked improvement over the older types. The knife is adjustable in three planes, to and from the object, side to side and the knife can be tilted with reference to the vertical plane. Sections may be cut from one to twenty-five microns. The object clamp shown in Fig. 3201 is more satisfactory, in the writer's opinion, than the object discs furnished with the machine.

In *cutting serial paraffin sections*, the new form of ribbon carrier is often used. This is easily adjusted to the microtome and insures an unbroken ribbon.

Another and late form of rotary microtome is shown in Fig. 3202. All the working parts are enclosed and protected. This instrument is said to have advantage over the others of the same type in that the object is not advanced until it is above the knife edge. The feeding mechanism is so arranged so that when the nut has reached its limit, the feed mechanism is automatically thrown out and the feed thread protected from injury. The object clamp is part of a ball that fits into a socket. The ball part of the object clamp is held into position and adjusted to any angle by means of three set screws. This clamp will hold either discs or blocks equally well. The up and down stroke of the block is two inches, permitting the cutting of unusually large specimens. The feed has a total excursion of thirty-seven millimeters, an exceedingly desirable property in serial sections as this permits the cutting of a whole embryo of nearly one and one-third inch length in one continuous operation. Sections from one to sixty microns in thickness may be cut with this instrument. An attachment for cutting celloidin blocks is made for this microtome.

A new instrument for cutting is the sledge microtome. This type is shown in Fig. 3203. The feeding or raising mechanism is free of the sliding motion of the carrier. This instrument has a ball and socket clamp and sections may be cut from one to twenty microns in thickness. Above twenty microns, sections may be cut by turning the knob the desired amount by hand. Fig. 3204 shows a dropping apparatus to flood the knife when cutting celloidin blocks.

The highest type of microtome is probably the "Precision" microtome of Minot. The latest model is shown in Fig. 3205. It is adapted for paraffin and celloidin work and is considered the most precise instrument for uniformity of sections. It cuts sec-

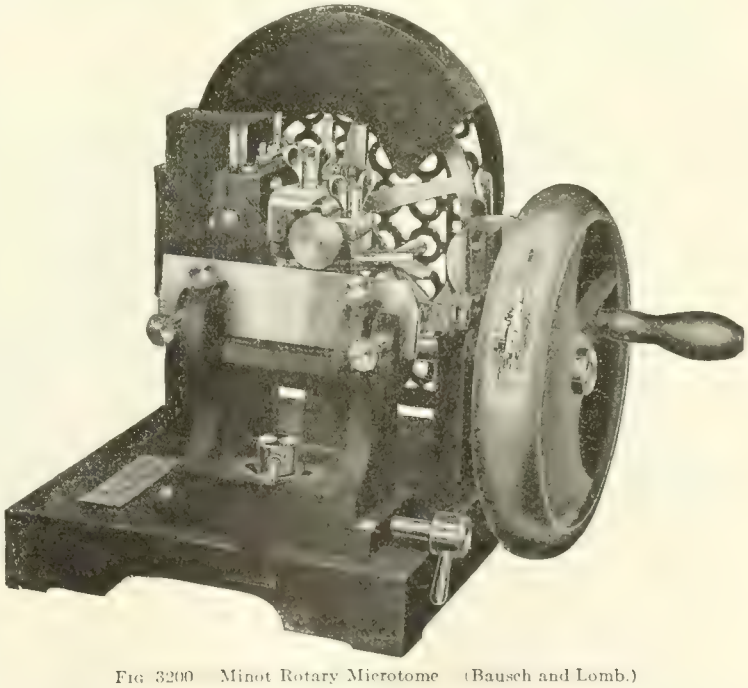

Fig. 3200.—Minot Rotary Microtome. (Bausch and Lomb.)

tions from one to twenty-five microns thick. The ribbon carrier may be attached to the back of the knife.

For sectioning slices of whole brains, an entirely different instrument must be used.

The "Precision" microtome of Minot (Fig. 3205) is a departure from the usual form of sliding microtome in that the knife is fixed and the object clamp is on a sliding carrier.

The knife is clamped to the frame of the microtome, and the object clamp

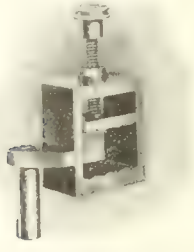

Fig. 3201.—Object Clamp.

carrier runs on slides under the knife. There is an automatic feed attachment that may be regulated so that sections from one to sixty microns in thickness may be cut. This microtome may be used for celloidin or paraffin preparations.

Whole brains are to be fixed in ten per cent. formalin for five to six months. The brain should be placed upon a deep bed of cotton and the formalin changed every few days the first week and once a week for the next few weeks. Mueller's fluid may also be used, but the nerve tissue is made very brittle and the myelin sheaths are stained satisfactorily by the technique here given. After fixing, the brain is cut into slices one centimeter thick and these are then washed and dehydrated in ascending alcohol as follows: 50 per cent. two to three days, 70 per cent. two to three days,

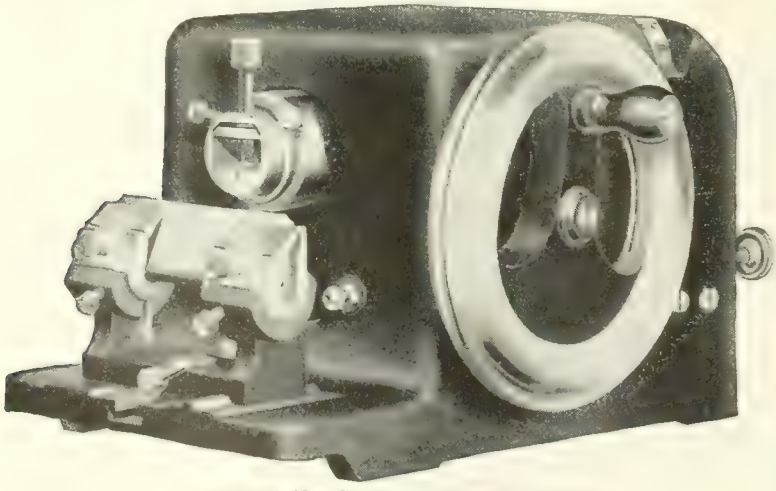

Fig. 3202.—New Rotary Microtome. (Spencer.)

95 per cent. four days, changing several times. Then clear in equal parts of absolute alcohol and ether for two to three days and place in thin celloidin for three to four weeks and block. The infiltrated brain is then mounted and sections cut at thirty to fifty microns thick. As each section is cut, it is floated upon a filter paper and lifted out of the bath and placed face down in a large staining dish of eighty per cent. alcohol. In this way the serial sections may be preserved in order and stained. The method of staining is that used for staining myelin sheaths after Weigert (see Stains). During staining, the paper over each section should be lifted until the stain has passed in and this should be done to every section in the dish. The differentiation should be carried on one section at a time, using the filter paper to transfer the sections.

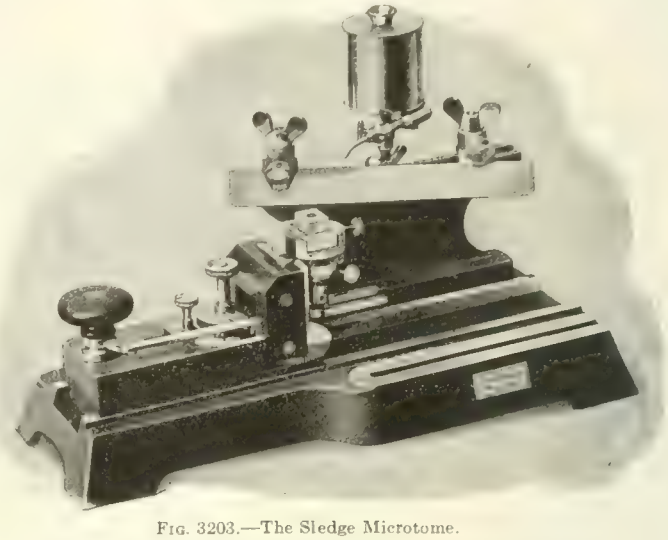

Fig. 3203.—The Sledge Microtome.

Microtome Knives.—The usual form of microtome knives is shown in Figs. 3206 and 3207. The upper surface is hollow ground so that when the knife is in the proper condition the edge should bend in waves when drawn flatwise over the thumb nail. As the edge wears off the knife must be hollow ground again. The under surface of the knife is flat. Its cutting edge is of a double chisel form, and must be perfectly straight. The knife should be heavy and its length adapted to the size of the microtome used.

A knife for cutting paraffin should be heavier than one used for celloidin.

In order to obtain good sections the cutting edge of the knife must be kept in the best possible condition. This is accomplished by stropping the knife frequently and honing it occasionally.

For honing, a yellow Belgian bone of large size is to be used. Its surface is thoroughly covered with a lather made with a pure soap and water. This lather is better made with a pure soap and water. This lather is better than oil as it keeps the pores open and gives a better grinding surface. In honing, one of the backs (Fig. 3206) is fastened to the knife. This is for the purpose of keeping the angle of the edge of the knife constant. The knife is first sharpened on its concave side, then turned and sharpened on the flat side. The pressure on the knife should be light; it should be drawn across the hone from heel to toe, the edge being drawn against the surface of the hone. The movements are illustrated in Fig. 3208. No amount of honing will be of any use unless the knife has a proper concavity. As honing is very precise work it is advisable to send the knives to a specialist for grinding and honing.

For stropping the best form of strop is that known as the bow strop (Fig. 3209). The movements of the knife are the reverse of those of honing, and are shown in the illustration. After use the knife should be carefully dried with a soft cloth.

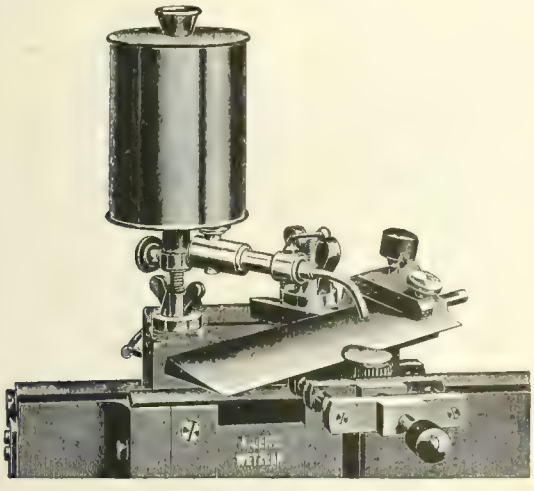

Fig. 3204.—Dropping Apparatus.

Tissues embedded in paraffin are *cut dry* and the knife must be at *right angles* to the block. The sections, if thin, are transferred to lukewarm water where they are allowed to spread out and are then drawn upon a slide prepared with *Mayer's albumen*. This is the beginning of *Slide Technique*.

Tissues imbedded in celloidin are preserved in eighty per cent. alcohol until wanted and then *cut wet*. The knife is placed *obliquely* so that the block traverses most of the cutting edge. The block and knife must be constantly flooded with eighty per cent. alcohol and the sections and blocks must never be allowed to dry. This can be done by the use of the apparatus shown in Fig. 3204 and the sections transferred to a container of eighty per cent. alcohol by means of a large camel's hair brush and kept there until wanted. The writer prefers the following technic: Moisten the block and knife with a large brush full of alcohol and after the section is cut and as the block passes the knife on the up stroke remove the cut section from the knife with an upward stroke of the brush full of alcohol; this removes the section and floods the block and the knife. If the sections are small, four or five sections may be removed in rapid succession with one wetting of the brush. If the sections are large, only one or two should be removed at a time. It is best to transfer

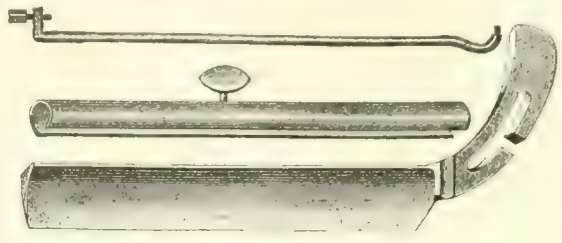

Fig. 3206.—Microtome Knife with Two Forms of Backs used in Honing and Stopping.

the sections to a conical graduate with the brush. If many sections are to be cut 500 c.c. graduate should be used and as the sections are placed therein, they sink gradually to the bottom, open out and uncurl.

Rapid Paraffin Method.—There is a *rapid method of technique* where more time can be allowed them for frozen sections and better results are acquired.

The steps are as follows: 1. Fix small pieces of tissue in formalin-Mueller eighteen to twenty-four hours (formalin 20 c.c., Mueller's fluid 80 c.c.). 2. Place in ninety-five per cent. for four hours, changing at the end of two hours. 3. Absolute alcohol ($CuSO_4$) twelve to twenty-four hours. 4. Anilin oil at 52° C. until transparent. 5. Paraffin at 46° C. for one hour. 6. Paraffin at 54° C. for three to four hours. 7. Block. This method requires only fifty-six hours or even less.

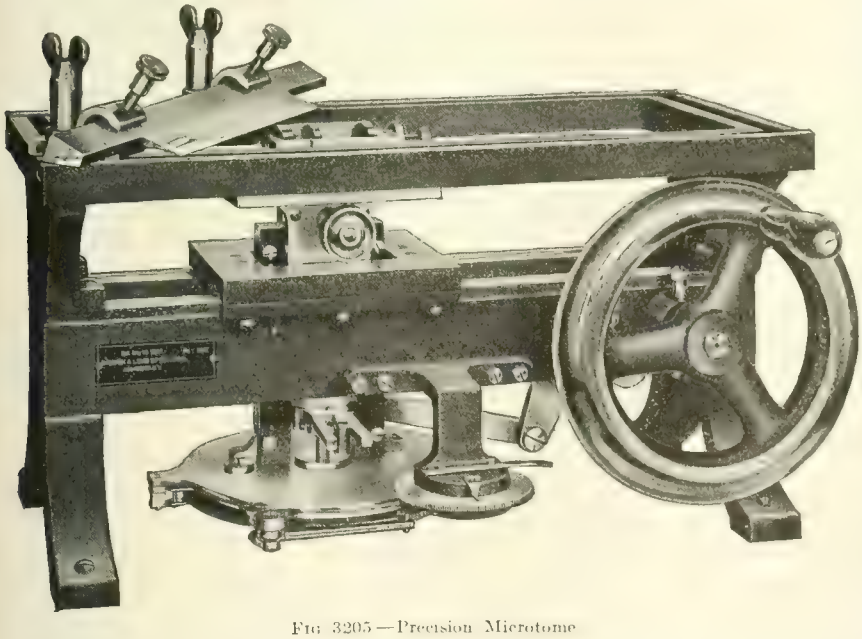

Fig. 3205.—Precision Microtome

Stains.—In order to study tissues after they are cut, the sections are mounted on glass slides and then stained. The various stains act differently upon a section, some showing an affinity for the chromatin of the nucleus and are then called *nuclear*, or *chromatic stains;* others affect the constituents of the cell body and are called the *protoplasmic*, or *plasmatic stains*. In addition, there are a class of stains that have affinity for certain tissues only. The other tissues of the section being uncolored or differently stained. These are the *special stains*.

The terms *acid* and *basic stains* are used, and these terms refer to the characters, *color acids* or *color bases* and not to those of the color salts. An *acid stain* is a compound in which the so-called color acid is combined with a non-staining base; in acid fuchsin (the sodium salt of rosanilin di- or tri-sulphuric acid) the coloring properties are due to rosanilin that exists as a base here and not to the hydrochloric acid of the

compound (Lee). An acid stain may have a neutral or alkali reaction and a basic stain may have an acid reaction. Acid stains are usually easily soluble in water and less so in alcohol, while the reverse is generally true of the basic dyes. Stains given by acid dyes are fast to acids and are usually intensified by them; basic stains are intensified by alkalies and removed by acids.

Neutral stains are those that are compounds of a color base with color acids and are usually prepared in the laboratory. If aqueous solution of basic and acid dyes be mixed, the neutral dye is precipitated as it is generally insoluble in pure water. It may be separated by filtration and the precipitate may then be dissolved in alcohol or may be dissolved in the mixture by adding an excess of either the acid or basic color used. The same results may be accomplished on sections by staining first with the acid dye and then bring the section, without washing, into the basic stain. This is especially true of *basic dyes* like *methyl green, methylene blue, amethyst violet, pyronin* and *rhodamin* and the *acid dyes, acid fuchsin, orange G* and *narcein* as pointed out by Ehrlich and Lazarus.

The *basic dyes* are usually *chromatin,* or *nuclear stains,* the *acid stains* usually *cytoplasmic* and *intercellular* while the *neutral stains* usually show an affinity for *certain cell contents.*

Mordants.—When substances absorb the stain from the solutions in which they are placed and combine directly therewith, they are said to be *substantively dyed.* Some dyes, however, will not stain directly and the sections or tissues must first be subjected to a *mordant* (usually a metallic salt or hydrate)

Fig. 3207.—Microtome Knife with Detachable Handle.

before the dye will act. These are then known as *adjective dyes.* (See Special Stains.)

Some stains give better results when the tissues have been fixed with certain solutions. Tissues that have been in contact with alcohol, react to stains better than those that have not, but long preservation in alcohol does not result in good stain reactions.

Intra vitam staining is employed to tinge the cytoplasm of cells and tissues in living condition without injuring their vitality. These are usually used in dilute neutral or faintly alkaline aqueous solutions and are mostly basic. Such stains do not affect the living nucleus and if the chromatin be stained, it indicates that that cell was dead when affected by the stain. The most important of this class of stains are *cyanin, methylene blue, Bismark brown, anilin black, Congo red, neutral red* and *Nile green* and under certain conditions, *eosin, dalhia* and *gentian violet.*

Tissues may be stained in bulk or in sections. If bulk staining is employed, the pieces of tissue should be small. This answers well for embryos and small fetuses, but for general cytologic work, the section staining is to be recommended.

Stains are employed in aqueous or alcoholic solutions. The aqueous solutions are generally preferred as their quality is better, but alcoholic stains penetrate more rapidly and injure the tissues less. Better results are usually obtained (as far as the stain is concerned) if sections are subjected to the action of a dilute stain for a long time, instead of a strong stain for a short time.

Nuclear, or Basic Stains.—In this class are found *hematoxylin, carmin,* and the *basic anilin dyes.*

Hematoxylin is the brownish crystalline extract of logwood and its staining property is due to the formation of *hematein* during the preparation of the stain. This is brought about by the *oxidation* or *ripening* of the solution. Hematein is a color acid, but when combined with a mordant as salts of aluminum, chromium, iron, copper, and others, it becomes a color base of high value and one of the best all-around nuclear stains.

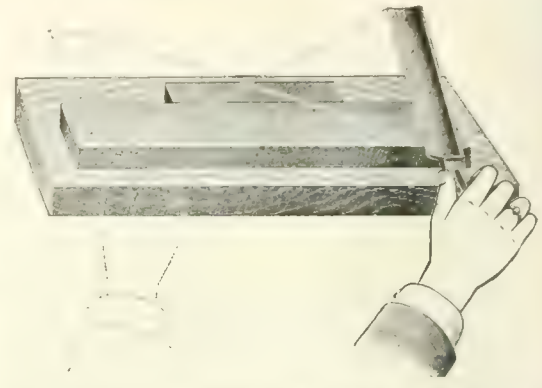

Fig. 3208.—Showing the Movements of the Knife in the Process of Honing.

Delafield's Hematoxylin.—Saturated aqueous solution of ammonium alum, 400 c.c. (1 of alum to 11 of water) add a solution of four grams of hematoxylin crystals in 25 c.c. of absolute alcohol. Expose to light and air for three to four days. Then filter and add 100 c.c. methyl alcohol and 100 c.c. glycerin. Leave uncorked until darkly colored. This ripening process requires at least two months. It should be diluted three to four times when used. Sections are stained in three to five minutes.

Harris's Hematoxylin.—Add one gram of hematoxylin dissolved in 10 c.c. of absolute alcohol to 200 c.c. of saturated solution of potassium alum. Bring to a boil and add one gram of red oxide of mercury, boil gently a couple of minutes, cool rapidly, and when cool, filter. This solution should be diluted two to three times for use. The oxygen liberated from the mercuric oxide causes *immediate oxidation* or *ripening,* so that this solution may be used when cold. It stains sections in three to five minutes. *Mayer* says this gives too much hematein.

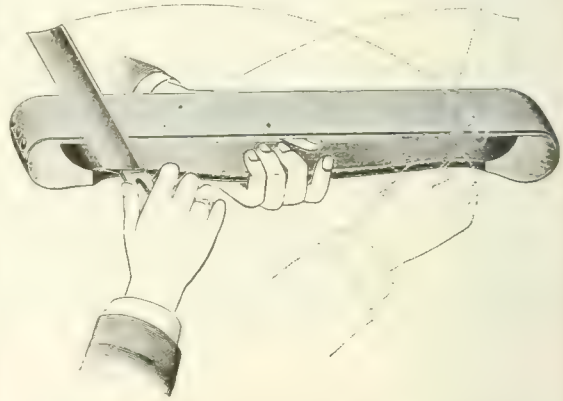

Fig. 3209.—The Bow Strop, and the Mode of Stropping.

Carrazzi's Hematoxylin (1912).—Hematoxylin 0.5 gram, potassium iodate 0.01 gram, alum 25 grams, glycerin 100 c.c., distilled water 400 c.c. Crush the alum in a mortar to hasten its solution. Mix all together in one liter flask at room temperature and when all are dissolved (usually several hours) it is ready for use. This solution is advantageous as it may be quickly

prepared and used and no precipitate forms after several years and it does not lose its staining qualities with age. It is diluted with equal or double volume of water before use and requires three to five minutes to stain.

Ehrlich's Acid Hematoxylin.—Dissolve two grams of hematoxylin in 100 c.c. of absolute alcohol, add 100 c.c. of glycerin, 100 c.c of water and 10 c.c. glacial acetic acid. To this mixture add alum in excess and expose to the light and occasionally to the air until dark red. It is then ready for use and is highly recommended for bulk staining, as it does not overstain.

Iron Hematoxylin (*M. Heidenhain*).—Place section for one-half to two or three hours in a one and one-half to four per cent. solution of ferric alum (clear violet crystals). Wash with water and stain one-half hour in a 0.5 aqueous solution of hematoxylin. Wash with water and place again in the ferric alum solution. This differentiates and clears out the stain. The slide should be washed from time to time and examined under the microscope in order to control the differentiation. When the proper point is reached, sections are washed for one-fourth to one hour under the tap, dehydrated, cleared with xylol, and mounted. This stain is especially useful in karyokinesis, the chromosomes, centrosomes and spindle fibers are black and cytoplasm usually unstained or gravish.

Mayer's Hemalum (*New Formula*).—Dissolve one gram hematoxylin in 1,000 c.c. water, add 0.2 gram of sodium iodate and 50 grams alum. Dissolve and filter. As this is not stable, it is better to add 50 grams of chloral hydrate and one gram of citric or acetic acid. It stains very rapidly and if used dilute a weak aqueous solution of alum is to be used. It is excellent for bulk staining, requiring twenty-four hours for large pieces of tissue. Sections and tissues must be thoroughly washed to remove the alum.

Rawitz (1909) recommends the following: Hematein 1 gram, nitrate of aluminum 10 grams, water and glycerin each 250 grams.

Mayer's Hemastrontium.—Rub one gram of hematein and one gram of chloride of aluminum until fine; add 60 c.c of seventy per cent. alcohol and 0.25 grams of citric acid and allow to dissolve. Then add 50 grams of strontium chloride.

Sections stained with hematoxylin are usually washed with tap water. If the stain is not deep enough, washing with a weak alum solution or water with a faint trace of ammonia will deepen the color. Then the sections should be thoroughly washed with tap water. Strong alcoholic solution of hematoxylin should be followed by seventy per cent. alcohol washing.

Metcalf claims that the fading of hematoxylin stained tissues when mounted in balsam was due to the acid reaction of the balsam and recommended that they be held over the mouth of a bottle containing ammonia, a few minutes, before applying the coverglass. Even then they fade at the edge. *Carazzi* maintains that the fading is due to staining in bulk with ordinary hematoxylin solutions and that if stained in sections this fading does not occur even if the balsam is faintly acid. He also claims that sections of tissues stained in bulk with his stain, will not fade even at the edges.

Carmine.—Carmine is a variable substance, containing free carminic acid, and especially an alumina-lime-protein compound of carminic acid. Its action is due to the carminic acid and the alumina.

Cochineal, or extract of pure alcohol tincture of cochineal is a carminic acid compound of some alkali other than lime.

Carmine is a double stain, that is, it differentiates both nucleus and cytoplasm, so that no other stain is usually necessary. It is especially useful in bulk staining of whole pieces of tissue or whole embryos.

Grenacher's Alum Carmine.—Boil 100 c.c. of a five per cent. solution of ammonium alum and one gram of powdered carmine; cool and filter.

Mayer uses five grams alum, two grams carmine, 100 c.c. water and boils one hour. This gives a stronger stain.

Iron Carmine (*Zacharias*).—Boil one gram carmine in 100 c.c of thirty per cent. acetic acid for twenty minutes. Filter, stain tissues for two to three hours therein, an drinse with dilute acetic acid. Transfer with glass instruments into a one per cent. of ammoniated citrate of iron. Sections are blackened in a few minutes and pieces of tissue in two to three hours. Wash thoroughly in distilled water. This is a good plasma and chromatin stain.

Iron Carmine (*Lee*).—Mordant sections for several hours in sulphate of iron made as follows: Sulphate of iron 80 parts, sulphuric acid 15, nitric acid 18, water 40. Wash the sections and stain for one hour in a 0.5 per cent. solution of carminic acid in 50 per cent. alcohol. Wash with 50 per cent. alcohol, dehydrate, clear, and mount in balsam.

Ammonia Carmine (*Ranvier*).—Dissolve carmine in water with a slight excess of ammonia. Place in a large dish and allow to dry and even putrify. Dissolve the dry stain in pure water and filter.

Acetic Acid Alum Carmine (*Hennegny*).—Boil an excess of carmine in a saturated solution of potassium alum. Cool and add ten per cent. of glacial acetic acid. Allow the solution to stand several days, then filter. This stain is concentrated and to be used properly, mix enough with distilled water to give a deep rose tint. Transfer the sections from alcohol to this stain and allow to remain twenty-four to forty-eight hours; wash thoroughly in distilled water. Dehydrate, clear, and mount in balsam.

Cochineal Alum Carmine (*Partsch*).—Boil powdered cochineal in a five per cent. solution of alum, cool, filter, and add a little salicylic acid to preserve.

Rawitz (1909).—Cochineal 4 grams, nitrate of aluminum (or ammonio-sulphate of cobalt) 4 grams, water 100 c.c., glycerin 100 c.c. This is used for staining sections only.

Alcoholic Borax Carmine (*Grenacher*).—Boil two to three grams of carmine and four grams of borax in 100 c.c. for an hour or more. Dilute with an equal volume of seventy per cent. alcohol. Allow this to stand several days and filter and add a small piece of thymol to preserve. This is especially used for bulk staining. Pieces of tissue or embryos are allowed to remain in this stain until well colored (for several days if necessary) and then placed in seventy per cent. alcohol containing four drops of hydrochloric acid. When the tissue is of a transparent appearance it is then washed with seventy per cent. alcohol and then ninety-five per cent. alcohol, dehydrated, cleared, infiltrated, and blocked. Sections are usually stained in about twenty minutes. They are then washed in acid alcohol until brick red, dehydrated, cleared, and mounted in balsam.

Alcoholic Cochineal (*Mayer's New Formula*).—Powder five grams of cochineal and rub up with five grams of chloride of calcium and 0.5 gram of chloride of aluminum. Then add eight drops of nitric acid (sp. gr. 1.20) and 100 c.c. of fifty per cent. alcohol. Bring this to a boil, cool and allow to stand several days (stirring frequently) and then filter.

Carmalum (*Mayer*).—Dissolve one gram of carminic acid and ten grams alum in 200 c.c. of distilled water using heat if necessary. Decant or filter and add 0.5 per cent. of salicylate of sodium. This is especially useful in bulk staining of embryos and osmicated tissues. Wash out with water unless a nuclear stain only is desired and then use alum solution carefully or a weak acid and then wash thoroughly with water.

Paracarmine (*Mayer*).—Dissolve 1 gram of carminic acid, 0.5 gram of chloride of aluminum, 4 grams of chloride calcium in 100 c.c. of seventy per cent. alcohol. Allow this to settle and then filter. Ob-

jects should not have an alkaline reaction. This is useful in bulk staining. If a nuclear stain is desired in sections, the stain should be washed off with a 2.5 per cent. solution of glacial acetic acid in alcohol.

Iron Carmalum (*De Groot*).—Dissolve one gram of ferric alum in 20 c.c. of distilled water and add one gram of carminic acid. To this add 180 c.c. of distilled water and warm; then add five grams of potassium alum and dissolve. When cool, filter and add 2 drops of hydrochloric acid.

Iron Cochineal (*Hansen*).—Cochineal 5 to 10 grams, ferric alum 3 grams, water 250 c.c., ten per cent. sulphuric acid 25 c.c. Boil for fifteen to twenty minutes. May be used for sections or bulk staining.

Picrocarmine (*Ranvier*).—To a saturated solution of picric acid, add carmine dissolved in ammonia to saturation. Evaporate to one-fifth of its volume in a drying oven and filter when cool. Evaporate the filtrate to dryness and the crystalline product is picrocarmine. This should be used as a one per cent. solution in water. Overstained sections may be treated with acid alcohol (0.5 per cent. hydrochloric acid in seventy per cent. alcohol).

Basic Aniline Dyes.—The most important *nuclear stains* are methyl green, safranin, Bismark brown, genetian violet, thionin, and methylene blue.

Methyl green is used chiefly as a nuclear stain in fresh unfixed tissues. It may be used as a strong aqueous or alcoholic solution; either must contain one per cent. of acetic acid. It affects only the chromatin of the nucleus, stains almost instantly without overstaining. It should be washed off with acidulated water, mounted in some acidulated aqueous medium containing a little methyl green in solution. Balsam mounts are difficult to obtain as the alcohol used in dehydration tends to wipe out the stain. Even in aqueous media the stain does not last long.

Bismark Brown.—Boil this stain in water and after a few days filter. It may be used on fresh tissues or those that have been fixed. It stains rapidly and does not overstain and sections so stained may be mounted in balsam. For staining Ascaris ova, Herla uses Bismark brown 0.25 parts, malachite green 0.25 parts, glycerin 10 parts, water 100 parts. Wash with weak glycerin.

Safranin O.—Most safranins are not readily soluble in water but are in alcohol. *Lee* prefers this safranin and uses a mixture of equal parts of a saturated solution in anilin water and a saturated solution in absolute alcohol. Sections may be stained for several hours and up to twenty-four hours and then should be washed with alcohol for thirty seconds to two minutes to differentiate. They may then be cleared and mounted in balsam. Clearing should be done in cedar oil, bergamot, xylol, or toluol. This stain is permanent.

Gentian violet may be used as an aqueous or alcoholic solution as safranin and keeps well.

Gram's method is useful in staining nuclei at times. In this method the sections are treated, after staining, with the following solution for two to three minutes or until they are black: iodine 1 gram, potassium iodide 2 grams, water 300 c.c. After treatment with this solution they are washed with alcohol until gray and then cleared with clove oil. In resting nuclei the nucleoli only are stained while in dividing cells the chromatin is deeply stained.

Thionin is soluble in water and used as a saturated solution. If sections are stained only a few minutes, the chromatin alone is colored and they may be dehydrated, cleared and mounted in balsam. If stained longer, they must be differentiated in alcohol or until the protoplasm is decolorized. Sections may then be cleared and mounted in balsam. As some claim that the thionin fades gradually in balsam mounts, it is recommended that sections be mounted in colophonium melted in a flame.

King (1910) makes a saturated solution of thionin in one per cent. carbolic acid and states that the color is permanent

Methylene blue itself is a basic stain. The commercial dye contains at times a reddish dye as an impurity and this has lately been found by Michaelis, Nocht, Reuter, and Giemsa to be *methylene azur*. This is an oxidation product of methylene blue, is a strong dye and has a *metachromatic action*. This forms in "ripened" and alkaline solutions of methylene blue and gives the stain called "polychrome methylene blue."

Strong (1913) recommends the following for rapidly ripening hematoxylin or methylene blue (polychrome): Dissolve one gram of silver nitrate in 50 c.c. of distilled water and add drop by drop dilute hydrate until precipitation ceases. Wash the precipitate with distilled water to remove the alkali, testing with litmus. This fresh precipitate is added to the hematoxylin or methylene-blue solution, which after standing one to two hours may be filtered and used.

Metachromatic stains are those (usually basic aniline dyes) that give to the different elements of the tissues different colors, *one* of these being the same as that of the solution of the dye, and the *other*, the *metachromatic color*, being the same as that of the free color base of the dye (Lee). *Safranin* stains nuclei red, but mucin and cartilage matrix orange; *methyl violet* stains blue ordinarily, but cartilage matrix, mucin, amyloid substance and mast cells red. Among other such stains are *toluidin blue*, *gentian violet*, *thionin*, etc. This peculiar stain reaction may be due to a chemical reaction or to impurities in the dyes.

Methylene blue may be used in either alcoholic or aqueous solutions.

Alcoholic methylene blue consists of a saturated solution of the dye in ninety-five per cent. or absolute alcohol and constitutes a stock solution. It is made up by diluting one part with nine of water.

Loeffler's Methylene Blue.—Sat. alcoholic solution of methylene blue 30 c.c., aqueous solution of potassium hydrate (1 to 10,000) 100 c.c. This solution keeps well.

Gabbet's Solution.—Methylene blue 2 parts, sulphuric acid 25 parts, water 75 parts. This is used in staining tubercle bacilli.

Unna's Alkaline (*Polychrome*) *Methylene Blue Solution.*—Methylene blue 1 part, carbonate of potassium 1 part, water 100 parts. Mix and allow to stand for months, during which time it "ripens" or *oxidizes*. This ripened solution may be purchased ready for use. It is used diluted one to ten or even more and is especially useful with eosin in staining mast cells and plasma cells.

Methylene Blue and *Eosin in Borax Solution.*—The following solutions are required and are to be mixed just before use. (*a*) Saturated solution of methylene blue in saturated solution of borax; (*b*) one-half per cent. bluish "eosin" in seventy per sent. alcohol; (*c*) saturated aqueous solution of borax. For use filter and mix 2 parts of (*a*), 1 of (*b*), and 2 of (*c*).

Treat sections with absolute alcohol and stain for ten or twenty minutes. Decolorize in a one per cent. solution of acetic acid, wash with water, then dehydrate in absolute alcohol, clear in xylol, and mount in balsam. Nuclei are blue, while red blood cells, cytoplasm, connective tissue and eosinophilous granules are rose red.

Epithelia and *lymph spaces* may be studied by the use of methylene blue. The membranes are placed in a four per cent. solution of methylene blue in physiologic salt solution for about ten minutes and then transferred to a saturated solution of picrate of ammonium for at least one-half hour. They are then washed in fresh picrate solution and mounted in glycerin. This will give cell outlines. To show the lymph spaces, the tissues should stain fifteen to thirty minutes. Permanent stains are obtained by fixing

the stain according to *Michailow* (1910) as follows: After staining and washing in picrate of ammonium, fix in an eight per cent. solution of molybdate of ammonium containing a trace of osmic acid or 0.5 per cent. of formalin. The solution should just be filtered and tissues allowed to remain for twenty-four hours at a temperature of 27° C., then wash with warm water, dehydrate thoroughly, clear in xylol and mount in *xylol dammar*, not balsam.

Nissl's Methylene Blue Method.—Fresh pieces of nerve tissue are fixed and hardened in ninety-five per cent. alcohol and sectioned without imbedding. Sections are stained with the following: Methylene blue (B pat.) 3.75 parts, Venice soap 1.75 parts, distilled water 1,000 parts. The stain should be at least three months old. Warm the stain with the sections in it to 65° to 70° until bubbles arise. Transfer for five to twenty seconds to a mixture of anilin oil (10 parts) and ninety-six per cent. alcohol (90 parts). As soon as no more color is given off place on a slide, blot, clear with oil of cajeput, blot, treat with a few drops of benzol and mount. The *tigroid bodies* of the nerve cells are stained a deep blue.

Lennhoff (1910) recommends polychrom methylene blue for two minutes, followed by carbol-methyl green-pyronin for twenty minutes.

Methylene blue is one of the most important *intra vitam* stains. This will be considered under *Injection Methods.*

Other basic dyes are *fuchsin, dahlia, toluidin blue, magdala red* and *anilin red.*

Plasmatic or protoplasmic stains are those that stain the *cytoplasm* and *intercellular substance.* These are chiefly acid dyes, although a few basic act in this manner.

Eosin is the most used protoplasmic stain. It is employed after the nuclear stain has acted and has been washed off. There are a number of eosins, some soluble in both water and alcohol and others only in alcohol and are rather diffuse stains.

Eosin is usually used as a half to one per cent. aqueous or alcoholic solution. It stains in one to two minutes and should be washed off with water, if an aqueous solution is used, otherwise alcohol is employed. *Hansen* adds 1 drop of two per cent. acetic acid to 9 c.c. of one per cent. eosin.

Eosin is a specific stain for blood cells and certain granules of the leucocytes (Lee). It is used extensively in hematology in connection with methylene blue.

Acid fuchsin is quite soluble in water. *Lee* recommends a 0.5 per cent. solution. Sections are stained a few minutes only, washed a few seconds with acidulated water and then with alcohol, cleared and mounted. Sections of tissues fixed in chrom-osmium fixatives may require twenty-four hours to stain.

Orange G is readily soluble in water and is to be used like acid fuchsin. It is of advantage in blood staining and in mixtures.

Picric acid is useful after carmin and hematoxylin, but it acts rapidly and must be carefully watched. It is used as a saturated aqueous solution and stains in fifteen to thirty seconds.

Picrofuchsin (Van Gieson).—Saturated aqueous solution of picric acid 100 c.c., one per cent. aqueous solution of acid fuchsin 5 c.c. Sections are to be stained one and one-half to two minutes, washed with water, dehydrated, cleared in oil of origanum and mounted in balsam. This is a *selective stain for white fibrous connective tissue,* staining it a *bright red* and epithelium and muscle tissue, a yellowish or brownish color, axis cylinders, nerve cells and neuroglial fibers, red.

Volker's Modification (1913).—Take 100 c.c. of an 0.1 per cent. solution of picric acid and 1 c.c. of 0.1 per cent. solution of acid fuchsin. Stain paraffin sections for a whole day in this mixture, wash quickly with water acidulated with acetic acid, alcohol, xylol, and thick balsam. For a fine stain of connective tissue do not use hematoxylin.

Wilhelm uses acid fuchsin 0.2 gram, picrate of ammonium 0.8 gram, absolute alcohol 10 grams, water 89 grams.

Weigert uses 10 c.c. of one per cent. acid fuchsin to 100 c.c. of picric acid solution for staining sections of the nerve system.

Pyronin is seldom used alone. *Pappenhein* uses the following: one per cent. solution of pyronin 1 part, one per cent. solution of methyl green 2 parts. Stain sections for five minutes, wash with water and then differentiate in a solution of hydroquinon or resorcin in absolute alcohol. Chromatin is stained green and cytoplasm red, but in tissue fixed in Flemming's or Hermann's solutions the opposite results.

Carbol-Pyronin-Methyl Green (Unna).—Methyl green 0.15 parts, pyronin 0.25 parts, alcohol 2.5 parts, glycerin 20 parts, 0.05 per cent. carbolic acid sufficient to make up to 100 volumes. Stain sections for five minutes at 30° to 40° C. Cool rapidly, wash dehydrate, clear in xylol, toluol, or oil of bergamot and mount in balsam.

Ehrlich-Biondi-Heidenhain Stains.—Sat. aq. solution of acid fuchsin (Rubin S) 20 c.c., sat. aq. sol. of methyl green (*OO*) 50 c.c. Add these while constantly stirring to 100 c.c. of a sat. aq. sol. of orange G. Dilute with 60 to 100 volumes of water; this stain should redden upon the action of acetic acid.

Stain sections for six to twenty-four hours, dehydrate, clear in xylol and mount in xylolbalsam. This stain reacts best in tissues fixed in some bichloride solution. Fifteen to twenty drops of 0.2 acetic acid added to 100 c.c. of diluted stain is said to sharpen and make it permanent.

Bonney's Triple Stain (1908).—Methyl violet 0.25 parts, pyronin 1 part, water 100 parts. Tissues should be fixed in bichloride or acetic alcohol solutions. Sections are stained in two minutes with the above, washed with water and wiped dry. Flood twice with the following stain: Boil and filter a two per cent. aq. sol. of orange G. and add it drop by drop to 100 c.c. of acetone until a flocculent precipitate is formed, which re-dissolves upon further addition of the orange solution. Wash the section quickly with pure acetone, pass through xylol and mount in balsam. The *cytoplasm* is *red, chromatin violet, connective tissue yellow,* and *keratin, violet.*

Congo red is used as a 0.5 per cent. aqueous solution and gives good results after Delafield's hematoxylin.

Ruthenium Red.—M. Heidenhain (1913) uses a dilute aqueous solution of ruthenium red to stain free hand cross-sections of dried tendons. The tendon cells and septa are stained a red and the tendon fibers are not at all affected or only faintly.

Other plasma stains are *neutral red, aniline blue, nigrosin, light green, methyl blue,* etc.

Special Stains.—Under this head are classed: (1) those that stain either by depositing a coloring substance in the form of a precipitate in certain tissues or spaces, as silver nitrate and gold chloride; (2) those that have a selective affinity for certain tissues, as elastica, reticulum stains, etc.

1. *Metallic stains* are silver nitrate and gold chloride and produce negative or positive impregnations. In the former, the intercellular substances alone are colored, while in the latter, cells alone are affected.

Lee states that stock solutions of nitrates and chlorides of osmium, uranium, gold, silver, and platinum keep better in clear bottles exposed to light, and the good sunning actually improves them. These metallic stains can be used only on living or very fresh tissues.

Silver Staining.—Corneal Lymph Spaces.—In the solid state, silver nitrate may be rubbed over the cornea of a freshly removed eyeball. This surface is then removed, placed in distilled water and then brushed with a camel's hair brush to remove the epithelium. Expose to the light and the silver nitrate

that has penetrated the intercellular lymph spaces will be reduced and turn black.

Endothelial Cells.—Remove the omentum, central tendon of the diaphragm or peritoneum of a freshly killed animal, wash in distilled water and stretch over a slide or in nested vulcanite rings. Place into a 0.75 per cent. solution of silver nitrate until opaque (ten to fifteen minutes); wash with distilled water and expose to sunlight until reddish-brown; then dehydrate, clear and mount in balsam. The cell outlines are stained black and the nuclei and cell contents are quite distinct.

Vascular Endothelium.—Narcotize a guinea-pig, or rat, and insert a cannula into the thoracic aorta and inject 50 to 80 c.c. of a 1 per cent. solution of silver nitrate into the vessels. In 15 to 20 minutes follow in the same cannula with 100 to 150 c.c. of 4 per cent. formalin solution. Open the abdominal cavity, remove some intestine with its mesentery, place in 4 per cent. formalin and expose to sunlight. When reduction is complete (reddish-brown color) remove small pieces of the mesentery, dehydrate, clear and mount in balsam. The endothelium of the vessels will be seen clearly outlined.

Szuts (1913) recommends the following for staining endothelium and nodes of Ranvier in nerve fibers: Mesentery or small pieces of nerves (of frogs) are impregnated fifteen minutes in a one per cent. solution of silver nitrate, washed with distilled water and mounted in formalin-glycerin (glycerin 10 c.c. formalin 1 c.c.) covered with a glass and exposed to the sunlight for five to ten minutes. Ring with cement. Reduction and conservation are permanent.

Nerve Cells and Processes.—Cajal-Golgi Method.—Place thin pieces of freshly removed nerve tissue for three days in the following solution: 2 to 2.5 per cent. potassium bichromate solution 8 parts, 1 per cent. osmic acid solution 2 parts. Blot off the bichromate solution and rinse tissues thoroughly with one-half to three-fourth per cent. silver nitrate solution and then place the tissues in some fresh silver nitrate solution, in the dark, for three days. Change the solution after the first eight to twelve hours.

Place the tissues for one to two days in the following: two per cent. potas. bichromate solution 20 parts, two per cent. osmic acid 2 parts. Rinse quickly in distilled water and place in fresh silver nitrate solution for thirty-six to forty-eight hours, dehydrate in ninety-five per cent. alcohol for twenty minutes renewing the alcohol several times. Dehydrate in absolute alcohol thirty minutes, transfer to absolute alcohol ether (equal parts) for twenty minutes, then celloidin for one-half hour and thick celloidin for ten to twenty minutes. Block the tissues and harden in chloroform and when hard (about ten minutes) place for about half an hour in the following: Carbolic acid (melted) 50 c.c., oil of thyme or cedar 50 c.c., oil of bergamot 25 c.c.

Section, keeping the knife and block moist with the same mixture of oils, mount sections on slides, blot off the oil, clear in xylol and cover with thick balsam. Do not use coverglass.

Neurofibrils. Bielschowsky's Latest Method.—Pieces of tissue 1 c.c. in size are fixed in formalin and placed in pyrodin for three to four days. Wash for several hours in frequent changes of distilled water and place in a three per cent. solution of silver nitrate at 36° C. for three to five days. Place in an oxide bath for twenty-four hours. Prepare the bath as follows: twenty per cent. solution of silver nitrate 5 c.c., forty per cent. solution of sodium hydrate 5 drops. To this add sufficient ammonia to dissolve the precipitate and then 100 c.c. of water. It is well to add a few drops of ammonia to this solution, which keeps only a few hours. Wash the tissues a couple of hours in frequently changed distilled water and reduce in twenty per cent. formalin, dehydrate and make paraffin sections.

Schlemmer recommends the following method of preparing the oxide bath and finds that it keeps several days. Add caustic soda in excess to the silver nitrate solution and wash the precipitate by decantation until free of soda. Then dissolve the precipitate in ammonia.

Sand's Method.—Fix pieces of tissue not over five millimeters thick for forty-eight hours in the following freshly prepared solution: acetone 90 parts, nitric acid 10 parts. Change this at the end of the first half hour and again within twenty-four hours. Wash for six hours in frequently changed acetic acid and imbed and block in paraffin. Wash sections and after removal of the paraffin, place in a twenty per cent. silver nitrate solution for three days at 37° C. Place for ten minutes in the following: gallic acid 5 parts, acetate of sodium 10 parts, tannin 3 parts, water 1,000 parts. This solution should be at least three days old and changed if it becomes turbid under ten minutes. The sections may be mounted at once or toned until gray (five minutes) in the following: two per cent. solution of sulphocyanide of ammonium 17 parts, two per cent. solution of gold chloride 3 parts, water 80 parts. Fix for a few seconds in a five per cent. solution of hyposulphate of sodium.

The *neurofibrils* in the cells, *dendrites* and *axones* are *grayish-violet.*

Golgi's Method for Intracellular Network in Nerve Cells.—Fix for six to eight hours in a mixture consisting of equal parts of saturated solution of arsenious acid, ninety-six per cent. alcohol and twenty per cent. formalin. Place for one to three hours or days in a one per cent. silver nitrate solution. Reduce in the following: hydroquinon 20 grams, sodium sulphate 5 grams; twenty per cent. formalin 50 c.c., water 1,000 c.c. Wash and carry through celloidin. Sections are to be toned in a solution consisting of sodium hyposulphate 30 grams, sulphocyanide of ammonium 30 grams, water 1,000 c.c. and ten per cent. of a one per cent. solution of gold chloride; tone until gray, then wash thoroughly, dehydrate, clear and mount.

Silver nitrate solutions (*Golgi's Method*) are also used in outlining the *secretory canaliculi* of the liver-cells, acid cells of the stomach, etc.

New Cajal Method (1912).—Fix pieces of nerve tissue 2 to 2.5 millimeters thick in the following: Uranium nitrate 1.0 gram, formalin 15 grams, distilled water 100 grams. Adult tissue is fixed in nine to eleven hours. Very young requires twenty-four to thirty-six hours; neuroglia and nerve fibers about twenty hours. Wash a short time in water, cut to 1 millimeter thick and transfer to 1.5 per cent. solution of silver nitrate for at least twenty-four hours, better thirty-six to forty-eight hours. Wash twice with water and transfer to a solution of 2 grams of hydrochinon, 6 grams formalin, distilled water 100 grams, anhydrous sodium sulphit 0.15 to 0.25 grams (enough to give the solution a straw color). Then transfer for one hour to fifty per cent. alcohol, then ninety-six per cent. alcohol-ether, celloidin and section. Clear in oil of origanum and mount in balsam. The nuclei may be stained with hematoxylin before dehydration. To stain the *neuroglia* the uranium nitrate should be left out of the fixing solution.

Gold chloride gives a *positive impregnation.* It is used somewhat for the study of lymph spaces, but is chiefly used on nerve tissues for which it seems to have an especially selective affinity. When used on fresh tissues it is called *pre-impregnation,* and when used on fixed and hardened tissues, it is *postimpregnation.* In the *former,* the nuclei are unstained, the protoplasm well stained and the axis cylinder appears reddish violet. If the *latter,* the nuclei are well stained, cytoplasm pale and axis cylinders black, differentiating the neurofibrils in the latter (*Lee*). It was formerly believed that tissues must be fresh

for gold staining, but it has been found that results are better if the tissues are put in a cool place for twelve to twenty-four hours before being subjected to the action of the gold chloride.

Pre-impregnation.—Ranvier's Formic Acid Method.—Take 4 parts of a one per cent. solution of gold chloride and 1 part of formic acid and boil. When cool, place small pieces of tissue therein; muscle requires about twenty minutes and epidermis one to two hours in the dark. Reduce in daylight in acidulated water, or in the dark in formic acid, 1 part and water 4 parts, for twenty-four hours.

Ranvier's Lemon Juice Method.—Place fresh tissues in lemon juice transparent (five to ten minutes up). Wash rapidly with distilled water and place for twenty minutes in one per cent. gold chloride in the dark. Wash again and transfer to 50 c.c. distilled water containing two drops of acetic acid for twenty-four to forty-eight hours, in the light. Such preparations are not permanent. To get permanent stains, reduction must be carried on in the dark in dilute formic acid (1 acid to 4 of water) for twenty-four hours. Mount in fifty per cent. glycerin with one per cent. of formalin.

Kerschner places tissues in a solution consisting of five per cent. formic acid 10 parts, and two per cent. osmic acid 1 part until brown, then washes and places for two to six hours in a one per cent. gold chloride (in the dark), washes with water and places for twelve hours in a twenty-five per cent. solution of formic acid in the dark followed by twenty-four hours in the light. Mount in fifty per cent. glycerin with one per cent. formalin.

Postimpregnation.—Apathy's Method.—Fix tissues in a sat. sol. of corrosive sublimate in 0.5 sodium chloride and one per cent. osmic acid. Infiltration may be either with paraffin or celloidin, but should be as rapid as possible. Sections are fixed to the slides and the bichloride removed with iodine (as in Slide Technic) and washed with water, put in formic acid for one minute and washed with water. Transfer for about twenty-four hours in gold chloride solution 0.1 to 1 per cent. wash with water and place (sloping) in one per cent. formic acid. The sections should face down so that the precipitate falls away. Reduction is carried on in the daylight in summer or a direct sunlight in winter, for six to eight hours without a break. If the acid becomes brown, it should be renewed. Lee recommends a weak solution of formalin with or without formic acid for reduction.

Stutz reduces as above for twenty-four hours, washes the sections and returns them over night to gold chloride and the next day again reduces in formic acid. Such sections are to be mounted in glycerin acidulated with one per cent. formic acid and are permanent stains. If sections blacken after mounting it shows that reduction has been incomplete. *Ranvier* recommends that sections be placed for a few days in alcohol as this stops the reduction of the gold.

Other Special Stains.—Osmic acid is a special stina for fat, coloring it black. Frozen sections or pieces of teased tissue stain rapidly in a one per cent. solution. Pieces of tissue may be fixed and hardened in a one per cent. osmic acid or better its bichromate mixtures and the fat is then insoluble in alcohol, chloroform and oil of cloves. In this way blocks may be imbedded in paraffin and sectioned. These sections should be mounted in chloroform balsam.

Sudan III is a rapid, cheap and reliable stain for fat. Frozen sections are treated a few minutes with ninety-five per cent. alcohol and then stained for a few minutes to twenty-four hours in a saturated solution of Sudan III in eighty per cent. alcohol. Wash quickly in eighty per cent. alcohol, then water and mount in glycerin or water. Balsam cannot be used. The fat is stained red.

Scharlach R.—Herxheimer uses this stain as follows: absolute alcohol 70 parts, ten per cent. caustic soda 20 parts, water 10 parts. Saturate with Scharlach R. Stain a few minutes and wash out with seventy per cent. alcohol. Lately this author recommends a saturated solution of this dye in equal parts of acetone and seventy per cent. alcohol.

Capsicum Red (Okajima, 1912).—Finely divide the pericarpium layer of the ripe capsicum and soak for several days in ninety to ninety-five per cent. alcohol, then filter the orange red solution. Evaporate to one-fifth of its bulk and filter. It is then ready for use. Tissues may be fixed in formalin or potassium bichromate. Frozen sections are to be made, stained with the above for five minutes or longer, washed with eighty per cent. alcohol, then water, and mounted in glycerin or glycerin jelly. Sections may be counterstained with hematoxylin. This stain lends itself to washing with alcohol better than Sudan III. It is an *elective stain for fat* and does not tinge the other tissues. It stains equally well the fat of sebaceous and ceruminous glands and the myelin sheaths of spinal cord and brain. Fat droplets in pathological conditions also respond well to this dye. The stain seems to be a permanent one and acts well even after celloidin infiltration.

Cyanin solutions stain fat an *intense blue.*

Van Gieson's stain is a special stain for white fibrous connective tissue, to which it imparts a *bright red* color. Sections so counterstained should be cleared in oil of origanum.

Picro-Nigrosin.—Freeborn's Method.—Mix 45 c.c. sat. aq. sol. of picric acid with 5 c.c. of a one per cent. aq. sol. of picronigrosin. Stain sections three to five minutes, wash with water, dehydrate, clear and mount in balsam. Nuclei blackish, connective tissue blue, and other tissues are yellowish.

Weigert's Elastica (Resorcin-Fuchsin) Stain.—Bring to boiling point 2 grams of fuchsin, 4 grams of resorcin and 200 c.c. of water, add 25 c.c. of a solution of liquor ferri sesquichlorati; stir and boil for three minutes. Cool, filter, and dissolve the precipitate upon the filter in 200 c.c. of ninety-five per cent. alcohol. Stir and boil until precipitate is dissolved. Cool and bring up to 200 c.c. with ninety-five per cent. alcohol and add 4 c.c. concentrated hydrochloric acid. Carbolic acid in the same proportion may be used in place of the resorcin.

Stain sections twenty minutes to one hour, wash thoroughly in ninety-five per cent. alcohol and counterstain thirty seconds in sat. picric acid solution. Wash with water, dehydrate, clear, and mount in balsam. Elastic fibers are stained a *bluish black* and other tissues yellow.

Unna's Orcein Method for Elastic Fibers.—Orcein 1 gram, hydrochloric acid 7 c.c., absolute alcohol 100 c.c. Stain sections in a covered dish over night or warm sections over a flame until the solution thickens (ten to fifteen minutes). Wash with ninety per cent. alcohol and then with water to fix the color and remove the acid; then dehydrate, clear, and mount in balsam. Elastic fibers are deep brown and white fibrous connective tissues, pale brown. The nuclei may be stained with polychrome methylene blue after washing the sections with water.

Mallory's Reticulum Stain.—Tissues must be fixed in corrosive sublimate or Zenker's fluid and may be imbedded in paraffin or celloidin. Stain sections for one to three minutes in a one-twentieth to one-tenth per cent. aqueous solution of acid fuchsin. Wash with water. Place sections for one to five minutes in a one per cent. solution of phosphomolybdic acid. Use glass or platinum in transferring celloid sections. Wash in two changes of water, stain five to twenty minutes in the following: Aniline blue (water soluble) 0.5 gram, orange G. 2.0 grams, oxalic acid 2 grams, water 100 c.c. Wash with water, dehydrate, clear in xylol or oil of origanum and mount in balsam.

Fibrilla of reticulum, amyloid and mucin stain blue; red blood cells and myelin sheaths, yellow, other ele-

ments red. To bring out the connective tissue more sharply, omit the acid fuchsin.

Myelin Stains.—Weigert's.—Fix pieces of the nerve system in potassium bichromate, though this is not necessary. The tissues are infiltrated with celloidin and cut twenty to thirty microns in thickness.

Place for twenty-four hours in a solution consisting of pot. bichromate 5 grams, chrom alum 2 grams, and water 100 c.c. Wash in water and transfer to the following: Copper acetate 5 grams, acetate acid (36 per cent.) 5 c.c., chrom alum 2.5 grams, water 100 c.c. Prepare this solution by adding the alum to the water, bringing to a boil, remove the heat and add the acetic acid; then add the copper acetate stirring until all are dissolved. The solution should be clear when cold and represents a *mordant.* Wash the sections carefully in water and stain fifteen minutes to one to two hours in the following: Hematoxylin 1 gram, absolute alcohol 10 c.c., lithium carbonate (sat. aq. sol.) 1 c.c., water 90 c.c. Wash until wash water is clear and soak in tap water several hours to deepen the stain. Differentiate with the following: Potassium ferricyanide 5 grams, borax 4 grams (if granular one-half the amount), water 200 c.c. Sections remain in this tissue until the gray nerve tissue becomes yellowish and are then washed thoroughly in water and allowed to remain over night in water. They may then be dehydrated, cleared, and mounted. The *myelin sheaths* are stained a *bluish-black.*

Wiegert-Pal Method.—Fix as in above and place cut sections in one-half per cent. chromic acid for several hours if chromium salts have not been used for fixation. Place in hematoxylin solution for twenty-four to forty-eight hours. Wash in water containing two per cent. of lithium carbonate to make sections bluish. Differentiate in a one-fourth per cent. aq. sol. of potas. permanganate until the gray nerve substance is yellowish-brown; then transfer to the following solution until the gray substance is almost colorless: potas. sulphite 1 part, oxalic acid 1 part, distilled water 200 parts. This solution acts in a few seconds and must be carefully watched. Wash thoroughly in water, dehydrate, clear and mount.

Marchi's Method for Degenerated Nerves.—Harden small pieces of nerve tissue for one week in Mueller's fluid, then transfer for a few days to a mixture of 2 parts of Mueller's fluid and 1 part of one per cent. osmic acid. Wash thoroughly in water, dehydrate, imbed in celloidin and cut sections. Sections should be mounted in chloroform balsam to retain the osmic acid. The *normal sheaths* are *yellow* and the *degenerated ones* are *black.*

Venderovič osmicates 0.5 centimeter-thick sections of formalin-fixed nerve tissue and gets increased depth of reaction.

Gilbert's Myelin Sheath Stain (1912).—Fix in corrosive sublimate, formalin, alcohol or any other good fixative and imbed as usual. Place sections for twenty-four hours in a solution of iron alum. Stain in molybdenum hematoxylin for twelve hours at 37° C. or for twenty-four hours at room temperature. May use Weigert's, Delafields or Bohmer's hematoxylin. Differentiate in Weigert's ferricyanide-borax solution, watching the process carefully, wash thoroughly in water, dehydrate, clear and mount.

In tissues fixed in formalin or Mueller's fluid, the sheaths are a deep blue; in those fixed in alcohol or sublimate gray or blackish-blue. *Axis cylinders* are *pale blue* or *grayish.*

Neuroglia, Mallory's Method.—Fix fresh nerve tissues for four days in ten per cent. formalin and then four to eight days in saturated solution of picric acid. Mordant four to six days at 37° C. in a five per cent. solution of ammonium bichromate, imbed in celloidin and section. Place sections for one-fourth hour in 0.5 per cent. solution of potassium permanganate, wash and transfer for one-fourth hour into a one per cent. solution of oxalic acid. Wash well and stain from two to twenty-four hours in phosphotungstic hematoxylin made as follows: dissolve one gram of hematoxylin in 80 c.c. of water, add 20 c.c. of a ten per cent. sol. of Merck's phosphotungstic acid and 0.2 c.c. of hydrogen peroxide (U. S. P.). Wash the sections, dehydrate, clear with oil of origanum and mount in balsam. *Axis cylinder* and *cells* are *pink,* while the *neuroglia* is *blue.*

To make this stain permanent after washing the hematoxylin off of the sections, place them in a thirty per cent. alcoholic solution of ferric chloride for five to twenty minutes, wash with water and finish as above. The nuclei and neuroglia are a clear blue and all other elements are *yellowish* or *grayish.*

DaFano fixes in a mixture of pyridin 72 volumes, fifty per cent. nitric acid 28 volumes, and stains according to Mallory.

Amyloid Stain.—Tissues may be stained fresh or after fixation, preferably in alcohol. Sections are stained in a weak solution of iodine for three minutes and washed in water. Treat in a one to five per cent. sulphuric acid solution and color will change from red to blue. Dehydrate, clear in origanum and mount in balsam. The *amyloid material* will be *blue.*

Mucin, Hoyer's Method.—Fix tissues in sublimate, imbed in paraffin and stain sections without removing the corrosive sublimate for five to fifteen minutes in a dilute solution of the thionin (2 drops of sat. sol. in 5 c.c. distilled water). Wash with alcohol clear in a mixture of oil of cloves and thyme, then oil of cedar and mount in balsam. The *mucin* is *red* and *other substances blue.*

Bruno fixes and stains the skin of a frog in a mixture of 1.25 per cent. formalin 100 c.c. and one per cent. solution of thionin 8 c.c. The *mucous glands* are *red.*

Glycogen.—Zieglwallner (1911) recommends the following fixing agent for the study of glycogen and fat in the same tissues. Trichloracetic acid 9 parts, two per cent. osmic acid twenty-four parts, glacial acetic acid 9 parts, aquæ distillatæ 58 parts. Small pieces of tissue were allowed to remain ten to twelve hours in the solution and are then washed with fifty per cent. alcohol for an hour or longer. The tissues may then be carried (preferable) through celloidin infiltration. Glycogen is soluble in water and alcohol solutions of less than fifty per cent. strength, but not in trichloractic acid or stronger alcohols. After sections are made, they are stained with Best's alkalin carmine and counterstained with *bleu de Lyon* for five minutes (10 grams stain in 250 c.c. absolute alcohol). Wash with absolute alcohol, clear with xylol and mount in balsam. *Fat black, glycogen red, nuclei blue.*

Mast Cells. Fixing and Staining (Strecker, 1912).—Small pieces of tissue are placed for twenty-four hours in the following: Formalin (forty per cent.) 100 c.c., alcohol (ninety per cent.) 100 c.c., toluidin blue six grams. Larger pieces remain in this solution several days. Place for several hours in seventy per cent. alcohol, changing once or twice. Transfer to ninety-six per cent. alcohol for several hours, then absolute alcohol, benzol and paraffin. In the sections the *mast cells* are *intense blue* and sharply outlined on a pale blue background. This is also a selective stain for the chief cells of the rabbit's stomach.

Plasma cells and *mast cells* are stained as follows: Sections of tissue, preferably hardened in alcohol are stained one quarter of an hour to over night in polychrom methylene blue. Wash with water, decolorize in water containing a few drops of glycerin-ether mixture for five to ten minutes. Wash well in water, dehydrate in absolute alcohol, clear with xylol and mount in balsam. *Nuclei* are *blue* and *granules* of the *mast cells red* and *those of the plasma cells* are *blue.*

Clearing.—After sections have been stained and dehydrated the alcohol must be removed by some agent that will allow the use of a permanent mounting

medium. There are a number of these *dealcoholization* reagents, some answering better for certain stains than others.

Creosote (*Beechwood*).—This oil clears readily and may be used with practically all stains. It has the advantage of not dissolving celloidin and is an excellent agent for general laboratory work of the students.

Cedar oil clears tissues readily in ninety-five per cent. alcohol and does not extract aniline dyes.

Oil of origanum clears rapidly, celloidin is not affected, but it removes aniline dyes somewhat. It is especially employed after Van Gieson's stain.

Clove oil acts rapidly, but dissolves celloidin and removes aniline dyes. Sections become hard and brittle and yellow with age. It acts better when mixed in equal parts with oil of bergamot.

Oil of bergamot does not extract aniline dyes or dissolve celloidin. It will, however, remove eosin.

Oil of Cajeput is useful after certain stain methods.

Xylol, Benzol, Toluol act very rapidly and require dehydration with absolute alcohol. They are useful with aniline dyes, but celloidin is rendered stiff and hard by them.

Carbol-xylol is excellent for large celloidin sections. This consists of xylol, 3 parts, and crystalline carbolic acid 1 part.

Carbolxylol-clove oil is prepared by the writer for clearing large sections in celloidin. This consists of carbol-xylol, 2 parts, clove oil, 1 part. This reagent keeps the celloidin soft and pliable so that upon blotting the sections flatten out and are not raised in ridges. It is especially useful after carmin, hematoxylin, and myelin stains.

Aniline oil clears readily from seventy per cent. alcohol. It is more useful in imbedding that section clearing as sections and mounting media becomes gradually brown.

Most of the oils require about five minutes for clearing, but the rapidly acting reagents (xylol, toluol, benzol) are best used by holding the slide in the hand while clearing and rocking to and fro until the section is cleared (one to two minutes). The xylol must be rapidly blotted and balsam quickly applied or the tissues may become hazy.

Mounting or Preserving.—After sections are cleared, the clearing agent is removed and the *permanent mounting medium* applied. There are a number of media and they differ according to the preceding steps.

The object of mounting is to make a permanent preparation. In the case of aqueous and glycerin mounts, this is not always the case, as evaporation occurs at the edge of the coverglass. This can be prevented by *ringing* the coverglass as will be explained later. This step is not necessary when the resins are used. The choice of mounting medium sometimes depends on the stain used as some of the anilin dyes fade rapidly in some media and slowly or not at all in others. When no such factor exists, the medium used should have a refractive index as near that of crown glass (1.518) of which the lenses are made, as possible.

Sections and tissues that cannot be dehydrated and cleared for special stain reasons, are mounted in *gum, syrup* or *glycerin*.

Farrant's medium consists of 4 ounces picked gum arabic, 4 ounces water and 2 ounces glycerin. Sections are covered with this, a coverglass applied and later a cement rim applied.

Gum and Syrup. (Apathy.)—Dissolve picked gum arabic 50 grams and cane sugar (not candied) 50 grams, in 50 c.c. of distilled water over a water bath and add 0.05 grams of thymol. This sets quickly and gets as hard as balsam. It is used for mounting preparations stained in methylene blue.

Brun's Glucose Mixture.—Mix 40 parts of glucose and 10 parts of glycerin in 140 parts of water. Then add 70 parts of camphorated spirits and filter. This is especially useful for mounting sections and objects stained with the aniline dyes as it preserves these colors. Tissues and sections so mounted must be protected from vaporation. The methods used are explained under *Cements*.

Glycerin Media. Plain glycerin is an excellent preserving medium. When diluted with water, structures are more easily examined and studied than in pure glycerin, but they are not so well preserved. To preserve in pure glycerin it is best to place the object for a few hours in a few drops of glycerin alcohol mixture (glycerin 1, alcohol 1, water 2 parts) so as to allow the gradual evaporation of the alcohol. It may then be covered with pure glycerin or glycerin jelly and sealed.

Glycerin jelly is a solid at ordinary temperature and must be softened with heat and then poured upon the object that has been previously treated with glycerin or water. It sets quickly. Lee recommends pure glycerin or euparal, however.

Brandt's Glycerin Jelly.—Soak gelatin for two to three hours in water, pour off the excess water and melt the gelatin and add to each part of gelatin 1½ parts of glycerin; after mixing thoroughly, filter through spun glass. Add a few drops of carbolic acid.

Heidenhain (1905) mixes 9 parts gelatin, 7 of glycerin and 42 of water, filters and to the filtrate adds, drop by drop, 14 parts absolute alcohol.

Fischer (1912).—To 5 grams borax dissolved in 240 c.c. of water, add 25 c.c. glycerin. Then add 40 parts gelatin and dissolve with gentle heat until the solution is somewhat thickened. This is fluid at ordinary temperature.

Resinous Media.—These media comprise *gum sandarac, Canada balsam, gum dammar* and *colophonium*. These are all solids and are liquified by the action of certain volatile solvents.

Sandarac media are used where the sections or objects would be injured if treated with absolute alcohol and an oil clearing agent. The objects are mounted in these media directly from ninety-five per cent. alcohol, or in special cases after passing through a mixture of medium and its solvent or by passing through isobutylic or propylic alcohol. These media are all solutions of the gum in *camsal* and other solvents.

1. *Camsal balsam* a solution of the gum in camsal and propylic alcohol.

2. *Camsal balsam* a solution of the gum in camsal and isobutylic alcohol.

3. *Euparal* is a mixture of camsal, sandarac, eucalyptol and paraldehyde and is colorless or green, the latter containing a salt of copper that intensifies hematoxylin stains (Lee). These media do not dry too rapidly and preserve the most delicate stains. Lee recommends euparal for the most delicate cytologic work and uses it as much as Canada balsam.

Canada balsam is a solid that dissolves rapidly in xylol, benzol, chloroform and turpentine. Xylol balsam is the most used and best for all general purposes. Benzol balsam sets more rapidly, while chloroform balsam is injurious to aniline dyes. Turpentine balsam sets slowly, but the index of visibility is much longer retained by sections mounted in it. It does not always form a homogeneous solution with balsam, however. Balsam should be neutral in reaction.

Apathy (1909) recommends the following: Balsam two parts, cedar oil (immersion) 1 part, chloroform 1 part.

Seiler's Alcoholic Balsam.—Solid Canada balsam is dissolved in warm absolute alcohol and filtered through absorbent cotton. Sections are not cleared but mounted herein directly from absolute alcohol. It is said to be an excellent medium.

Dammar.—Gum dammar is soluble in xylol, benzol,

chloroform and turpentine. Xyloldammar is the best. It has the disadvantage that sooner or later granules appear in the preparations.

Colophonium.—Pale colophonium is dissolved in pure oil of turpentine to form a solution of medium consistency. This sets slowly and is injurious to alum hematin stains, but is excellent for methylene blue and other general stains.

After the sections are ready for mounting, a drop or two of the selected mounting medium is placed upon the object and a clean coverglass is applied.

Cements.—Aqueous and glycerin mounts are rendered permanent by painting the clean edges of the coverglass with a layer of glycerin jelly and repeating this several times after allowing each coat to set. This seals the coverglass.

Rousselet closes aqueous mounts with a mixture of 1 part gold size and 2 parts of dammar dissolved in benzol. Three or four rings should be applied at intervals of twenty-four hours.

Apathy uses the following for glycerin mounts: Hard paraffin (60° C.) and Canada balsam equal parts. Heat in a porcelain dish until no odor of turpentine is given off. It must be applied warm and one application is sufficient.

Ward's brown cement consists of shellac dissolved to the desired consistency in wood naphtha and alcohol. Add 20 drops of castor oil to each ounce. Glycerin mounts should first be ringed with glycerin jelly before applying the cement. It can also be used for balsam mounts.

Slide Technique.—Having considered the various steps necessary to prepare a piece of tissue for sectioning and having considered the various classes of stains, it is desirable now to consider the various steps necessary to prepare a section for microscopic study, that is, Slide Technique.

Fig. 3210.—Staining Jar for Sections Mounted on 1'' × 3'' Slides.

Paraffin sections are made to adhere to the slides by means of *Mayer's albumen.* This consists of 50 c.c. of white of egg, 50 c.c. glycerin, salicylate of soda 1 gram. Shake thoroughly and filter. Filtration is a slow process, but the solution keeps indefinitely.

1. Cover a clean slide one inch by three inches with a thin film of albumen (rubbing with the finger).

2. If the sections are under ten microns thick, they are floated on a bowl of water below the melting point of the paraffin, to float and spread the sections. They are then drawn upon the slide by dipping the latter under the surface. If ten microns thick, the sections are transferred by means of a moist brush to the "buttered slide" upon which several drops of water have been placed. The section is then oriented and gently warmed over a flame, without melting the paraffin, to remove wrinkles and to get it flat. The water is then drained off and the sections are labelled and set aside to dry either at room temperature (six to twenty-four hours) or in an oven for a couple of hours to drive off the water. Sections may be mounted on slides without water and albumen or by the aid of water without albumen. When thoroughly dry the slides are placed in a jar of xylol for five minutes to remove the paraffin; benzol, turpentine or kerosene will do, but xylol is the best.

4. Wash the slide with alcohol to remove the xylol and place in a jar of ninety-five per cent. alcohol for a couple of minutes. If the tissue has been fixed in a corrosive sublimate solution (otherwise omit) it is to be transferred to jar of

5. Iodine for five to seven minutes to remove the sublimate. The iodine solution consists of 50 grams of resublimed iodine in 3,000 c.c. of ninety-five per cent. alcohol.

6. Wash with alcohol and place in a jar of alcohol for fifteen minutes to remove the iodine. If bleaching is slow it may be hastened by using alcohol containing a little potassium iodide.

7. Stain. If aqueous stains are used, wash the section with water and cover with hematoxylin or place in a jar of hematoxylin for five minutes. Wash with tap-water and

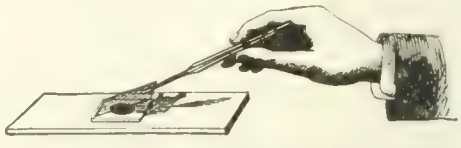

Fig. 3211.—Placing the Cover Glass in Position.

8. Stain with (aq.) eosin for two to three minutes, or Van Gieson's stain one and one-half to two minutes.

9. Wash with water and then alcohol and dehydrate in a jar of alcohol for 5 minutes.

10. Clean the slide carefully and then blot the alcohol off with tissue paper and apply

11. Creosote, oil of origanum, cedar oil, or any of the desirable or required clearing agents for 5 minutes.

12. Drain off the clearing agent, blot off the remainder carefully, put a drop of balsam upon the specimens and apply a clean coverglass.

Fig. 3210 shows a jar for ordinary slides. Each one will accommodate ten slides back to back. A set of these should be on hand, one for each reagent, except oil for clearing. This step should be carried on with each slide individually.

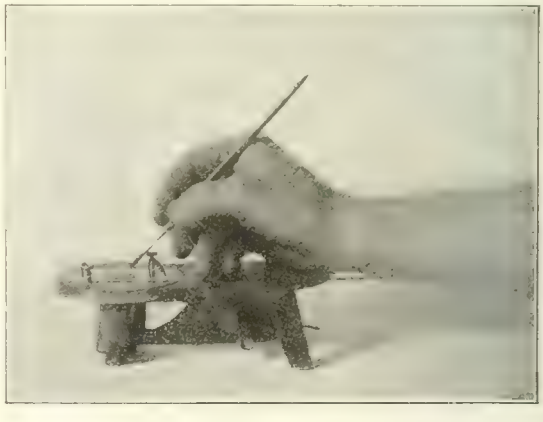

Fig. 3212.—Electric Turntable for Ringing Slides.

Cementing.—The coverglass is to be applied as shown in Fig. 3211. Squares or circles may be employed. If square coverglasses are used a thin layer of cement is applied at the edge and allowed to dry. If the circular cover is used the slide is placed upon a turntable (Fig. 3212) and a ring of cement applied.

In all these steps, the sections must *never be allowed to dry* and if the succeeding reagents are alcoholic and the section is in water, it must be washed with alcohol and *vice versa.*

Celloidin sections are usually stained in watch-glasses or upon the slides without cementing them. These watch-glasses (Fig. 3213) are so constructed as to fit upon one another so that they may be nested to

prevent evaporation of the reagent. Those with the ground slanting surface are to be preferred as notes or numbers may be made with a china-marking pencil and serial sections kept in order. They may be mounted on slides with Mayer's albumen and the celloidin may then be removed with a solution of ether and absolute alcohol. They must be carefully and thoroughly pressed upon the albumen which must not be too wet.

For serial sections on two inch by three inch slides the tray devised by the writer is recommended (Fig.

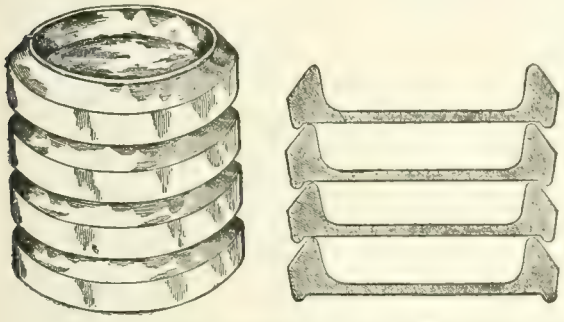

Fig. 3213.—Improved Syracuse Solid Watch Glass for Staining Celloidin Sections.

3214). The tray is constructed of aluminum and holds ten slides. It is light and can be used in most of the reagents used and is made so as to put in a one quart Barclay candy jar. With a half dozen trays and about eight jars for the various stains and wash solutions fifty slides can readily be run through in a couple of hours.

Serial sections of celloidin tissues may be mounted and this *Graham Kerr* (1908) does on a kodak film. The emulsion is removed with hot water and the film

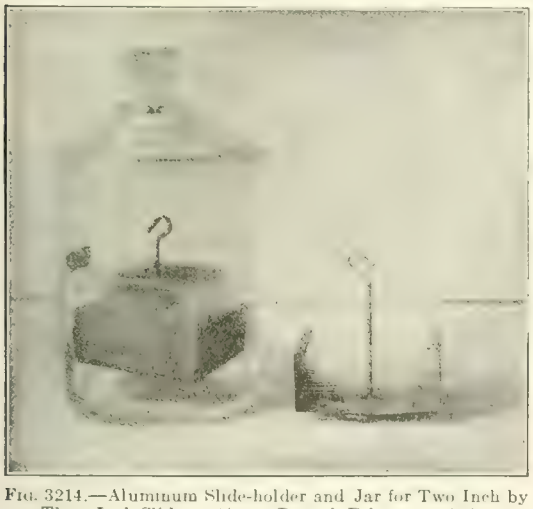

Fig. 3214.—Aluminum Slide-holder and Jar for Two Inch by Three Inch Slides. (Anat. Record, February, 1913.)

dried. The sections are arranged serially as cut upon the film and cemented thereto by a drop of absolute alcohol and ether or an atmosphere thereof. The sheets may then be stained and mounted or rolled up and stored in cedar oil.

Decalcification.—In order to study hard substances like teeth or bone, they may be prepared in one of two ways: (1) by *grinding*, or (2) by *decalcifying*.

1. *Grinding.*—Macerate a fresh bone or a tooth for a while to get rid of the fat and soft parts, then wash and dry. Cut thin sections with a sharp saw. These may be cemented to a small plate with sealing wax and then ground down about half on an emery wheel, unsealed and sealed with the ground side to the plate and then ground until quite thin. The sections are then carefully removed and ground by hand on a water hone to the required thinness, examining from time to time under the microscope, polished, washed, dried and mounted in balsam. In order to cut in a microtome, the earthy substance must be removed by the process of *decalcification*. The lime salts are removed by the means of acid solutions, but not until the organic material has been thoroughly fixed and hardened.

Large quantities of the liquid are to be utilized and as the decalcifying solutions produce more or less swelling of the tissues, the fixation and hardening should produce some shrinkage. After decalcification is completed, a needle should penetrate the tissue without any difficulty. The tissues must then be thoroughly washed to remove the free acid and in addition some recommend the use of some carbonate to neutralize the acid. The time required for decalcification depends upon the size of the pieces of bone, so that the needle test is the only reliable means of determining the completion of the process. Decalcification is usually done before imbedding, but some prefer to infiltrate with celloidin and then decalcify.

Decalcification After Imbedding in Celloidin.—Fix in any good fixing agent (some bichromate solution preferred), dehydrate, clear and imbed in celloidin and harden in eighty-five per cent. alcohol. When hard, transfer to eighty-five per cent. alcohol containing ten to forty per cent. of strong nitric acid until decalcification is complete. Wash out the acid in alcohol containing precipitated carbonate of lime and then cut sections. This is especially adapted to porifera, corals, etc. Stein prefers this method in decalcifying temporal bones of mammals.

Phloroglucin-nitric Acid.—Dissolve one gram of phloroglucin in 5 c.c. of concentrated nitric acid. After the fumes have ceased to form, 100 c.c. of seventy per cent. alcohol are added. If desired, nitric acid may be added up to twenty per cent., but this amount is not recommended. This is one of the most rapid decalcifiers. The phloroglucin protects the organic substance from the swelling action of the acid. Fetal bones are softened in one-half hour and pieces of adult bone in four to five hours. The tissues are then thoroughly washed in running water for a number of hours, dehydrated, cleared and infiltrated with celloidin, preferably.

Hydrochloric acid may be used in place of the nitric acid using 30 c.c.

Decalcification before Imbedding.—Nitric Acid.—Busch.—Place pieces of fresh bone for three days in ninety-five per cent. alcohol and then place in a solution of 1 part of pure nitric acid (sp. gr. 1.25) to 10 of water, for eight to ten days, changing the solution frequently. Young bones are placed in a weaker solution. When decalcified, wash for several hours in running water and then place in ninety-five per cent. alcohol for several days, changing frequently.

Schaffer (1903) recommends the following method: Fix and imbed in celloidin and harden in alcohol, place in water to remove the alcohol; place (small specimens) twelve to twenty-four hours in three to five per cent. nitric acid. Transfer to a five per cent. solution of sulphate of lithium or sodium for twelve to twenty-four hours, changing once. Wash in running water, dehydrate to eighty-five per cent. and cut.

Mayer uses a five per cent. nitric acid solution in ninety per cent. alcohol after fixation. This requires several days or weeks.

Thoma prefers 1 volume of pure concentrated nitric acid and 5 volumes of ninety-five per cent. alcohol. This requires several weeks and should be changed every two or three days. Wash out acid with ninety-five per cent. alcohol containing precipitated carbonate of lime in excess, which may take eight to fourteen days.

Nitric Acid Alum.—Take equal parts of saturated solution of alum and distilled water and add five per cent. concentrated nitric acid. Change every few days until decalcification is complete. This is said to be especially good for decalcifying teeth.

Nitric Acid and Formalin.—*Schudde* (1910) fixes in formalin or formalin-Mueller solution and decalcifies in a solution containing 1 part nitric acid, 1 part formalin, and 9 parts water.

Hydrochloric Acid.—This is widely used, but is not the best decalcifier. Its action is rapid, but the swelling is marked. When combined with alcohol or chromic acid and other agents, this fault is reduced to a minimum.

Hydrochloric Acid and Sodium Chloride.—*Von Ebner* takes 100 c.c. saturated sodium chloride solution (cold), 100 c.c. water and 4 c.c. strong hydrochloric acid. One to two cubic centimeters of acid are to be added each day until decalcification is completed.

Haug prefers a mixture of the following: Alcohol 70 c.c., water 30 c.c., sodium chloride 0.5 gram, hydrochloric acid 1 to 5 c.c.

Hydrochloric Acid and Chromic Acid.—Equal parts of three per cent. solution of chromic acid and one per cent. hydrochloric acid is recommended for cartilage that has ossified.

Hydrochloric Acid and Palladium Chloride.—*Waldeyer* uses a one one-thousandth per cent. solution of palladium chloride added to one-tenth of its volume of hydrochloric acid. Tissues are left here until softened, changing the solution every day or two.

Chromic acid is a slow decalcifier and is used in a 0.1 per cent. to two per cent. solution. It is better to start with a weak solution and gradually increase the strength.

Picric acid in a saturated solution is only adapted to small objects as young embryos, and is a very slow reagent. It must be frequently renewed. *Picronitric* and *picrohydrochloric* acids act more rapidly.

Sulphurous acid as a saturated solution in water acts rapidly and best after formalin fixation. Tissues must be washed twenty-four hours.

Trichloracetic acid is used as a five per cent. solution in water. It acts more slowly than nitric acid, but preservation is excellent.

If decalcification has been carried out before imbedding, the tissues are washed to free of acid and dehydrated, cleared in oil and imbedded with paraffin, or cleared in alcohol-ether mixture and infiltrated with celloidin. The latter is preferable as heat tends to harden the decalcified tissues and makes sectioning difficult.

Injection.—In order to study the blood-vessels and lymph-vascular channels of the body, the vessels are filled or injected with some mass that outlines them. Injection is also used for the study of nerve organs and for the preparation of corrosion specimens.

Self-injection of the Living Animal.—This is accomplished by allowing a definite quantity of blood to escape from an opening in a vein of a living animal, and replacing the blood lost by some innocuous coloring matter, so that by the contractions of the heart the vessels are filled with much less injury than by an injection apparatus.

Chrzonszczewsky recommends a solution of 7.75 grams of carmine in 3.6 c.c. of ammonia, to which is added 30 c.c. of distilled water. This fluid is to be filtered before injecting. Ten cubic centimeters of blood are removed from the jugular vein of a medium-sized rabbit, and 10 c.c. of the above fluid injected. If the larger vessels are now rapidly ligated, first the vein and then the artery, a physiological injection of the blood-vessels is obtained. Good results are obtained in the case of the kidney, spleen, etc. The injection may also be accomplished by placing the above fluid in the stomach, rectum, and abdominal cavity; and in amphibia by placing it in the lymph cavities. After the injection is accomplished the organs are placed in acidulated alcohol, to cause the fixation of the carmine.

This solution, as well as the sulphindilate of sodium, then injected in large quantities, is rapidly excreted by the kidneys, and the latter substance is precipitated in the biliary passages. If the ureter is ligated immediately after injecting a rabbit and the animal is killed at the end of an hour, the urinary tube will be found filled with carmine. In injecting the biliary passages it is not necessary to ligate. The blood-vessels of the organ are to be washed out and the original coloring matter that remains in them is to be replaced with another. The organs injected with the sulphindilate of sodium, after the blood-vessels have been washed out, are placed in a concentrated solution of calcium chloride, then in alcohol, when the coloring matter will become fixed.

Heidenhain found that the commercial indigo-carmine was composed of a mixture of substances, generally three in number: (1) indigo blue-sulphate; (2) indigo blue-hyposulphate; (3) phenizine-sulphate of sodium. He found for the purpose of injection that 1 and 3 were the only ones useful. He injects 25 to 50 c.c. of a cold-saturated solution of one of the above salts into the vein of a medium-sized rabbit, and 50 to 75 c.c. into that of a medium-sized dog. After the animals have passed blue urine for some time they are killed by bleeding, and the coloring matter is fixed by injecting the kidney through the renal vessels with absolute alcohol.

For injecting the biliary passages of the frog, he places a piece of indigo-carmine, the size of a pea, in the lymph sac of the thigh, and closes the wound in the skin firmly. After twenty-four hours the biliary passages will be found beautifully injected.

Methylene Blue.—*Intra Vitam Injection.*—Amstein injects about 4 c.c. of a saturated solution of methylene blue, in physiologic salt solution, into the vena cutanea magna of a living frog and after one hour removes the organ to be examined. Apathy recommends a 1 to 1,000 solution while Dogiel prefers one-eighth to one-fourth per cent. solution. For warm-blooded animals this solution should be 36° to 39° C.

Organs.—In injecting organs, the cannula is tied into the artery of one freshly removed. The solution used is prepared as follows: Heat one gram of methylene blue (rectified) in 100 c.c. of normal salt solution until hot; allow this to cool, then filter. Inject this until a bluish color is imparted to the organ and leave undisturbed for one-half hour. Make thin sections or cut into small pieces and place in normal salt solution and expose to the air until the nerve organs are satisfactorily stained. Examine from time to time under the microscope and when the stain has reached its maximum fix in a sat. aq. sol. of ammonium picrate for twelve to twenty-four hours; transfer to a solution of equal parts of sat. sol. of ammonium picrate and glycerin for twenty-four hours. Mount in ammonium picrate glycerin. This treatment is used to *make the stain permanent.*

Mayer injects, subcutaneously, 20 c.c. normal salt solution containing one to four per cent. of methylene blue into young rabbits and repeats in one to two hours. Within the next two hours the animal will die. Remove the nerve system and carry small pieces through by *Bethe's Method.*

In order to make sections, pieces of methylene blue stained tissues are treated as follows: Place thin pieces in cold solution of one gram of ammonium molybdate dissolved in 10 c.c. water (using heat) and 1 c.c. of hydrochloric acid. This solution must be kept at 2° to 5° C. for the first few hours and after twelve to twenty-four hours the tissues are washed in distilled water. Harden and dehydrate quickly in absolute alcohol, clear in xylol and imbed in paraffin. Make sections and stain with alum cochineal. Dehydrate,

clear in oil of bergamot, wash with xylol and mount in balsam.

Bethe's Method.—Pieces of tissue not over three millimeters in thickness are placed for ten to fifteen minutes in a sat. aq. sol. of picrate of ammonium. Transfer to a solution consisting of one gram of ammonium molybdate in 20 c.c. of water (or 10 c.c. water and 10 c.c. of 0.5 per cent. osmic acid). In the first solution they remain three-fourths to one hour and in the second four to twelve hours. Wash thoroughly with water, dehydrate, clear in xylol, and imbed in paraffin.

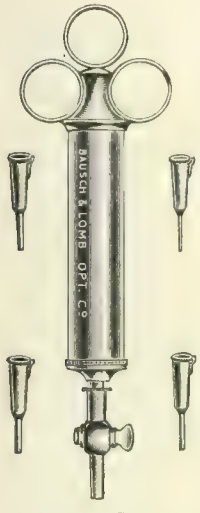

Fig. 3215.—Syringe for Injection by Hand.

Michaelow (1910) places pieces of tissue in an eight per cent. solution of molybdate containing 0.5 per cent. of formalin for twenty-four hours at 37° C. washes with warm water, dehydrates, clears in xylol, and mounts in xylol dammar.

Injection Technique.—The blood-vessels are injected after killing the animal with ether or chloroform, then either the entire vascular system may be injected or only individual organs. It is best to keep the animal warm during the process of injection. Injection may be carried on by means of a *syringe* or by a *constant pressure apparatus.* The *former* requires experience as constant pressure must be maintained. The syringe is shown in Fig. 3215 and consists of the syringe, stopcock, and several cannulas of different sizes. If a *complete injection* is desired, the thorax of the animal is opened, the pericardium incised and the left ventricle opened and a suitable warm cannula inserted into the aorta and tied there by a ligature that is tied over the hook of the cannula to prevent it from slipping out. A second ligature is passed around the aorta in front of the end of the cannula and left untied until the injection is finished. The stopcock should then be taken from warm salt solution and attached to the cannula; the warm syringe filled with the injecting fluid should be turned up and a few drops expelled to remove all air. The syringe is then fitted into the stopcock and the contents gradually expelled into the vessels. The stopcock is closed and the syringe filled and emptied as often as is necessary to complete the injection. The second ligature is tied, the stopcock removed and the animal is plunged into ice water, if a warm mass has been used, until cold.

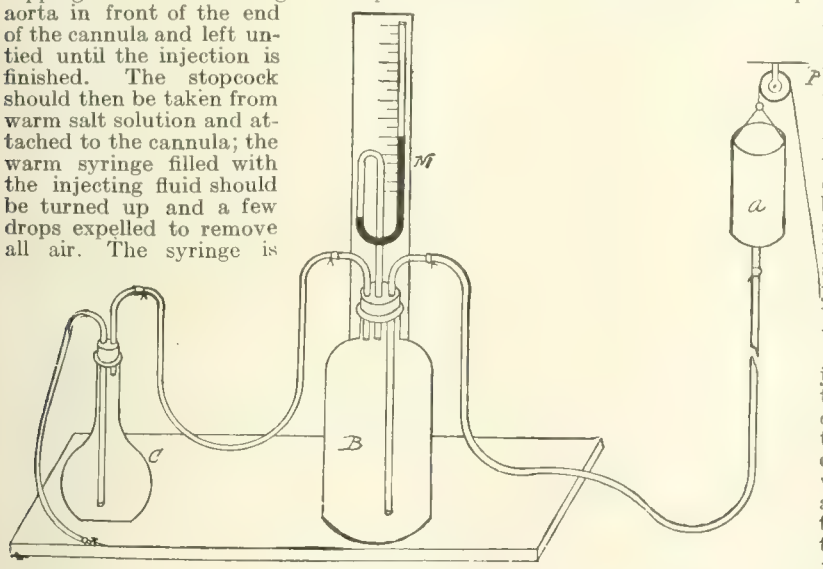

Fig. 3216.—Water-pressure Injecting Apparatus.

A *single organ* may be injected in the same manner through its artery and ligating both artery and vein after injection. *Double injections* may be obtained by injecting the artery and vein at the same time. A *constant pressure apparatus* is then recommended, using low pressure at first to fill the large vessels and then increasing the pressure to fill the capillaries. Some recommend washing the vessels or vascular system with normal salt solution before injecting. Constant pressure may be produced by means of water or mercury. Fig. 3216 shows one operated by water.

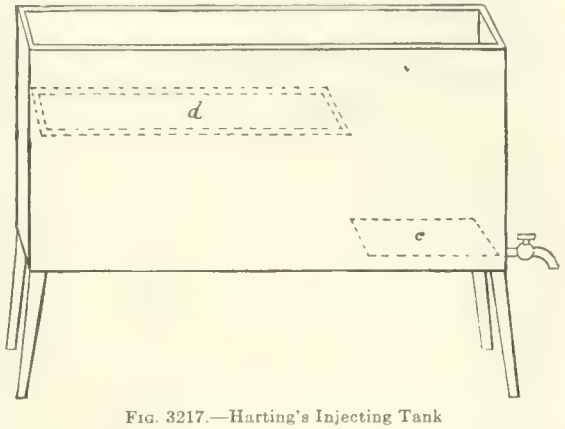

Fig. 3217.—Harting's Injecting Tank

The water-pressure apparatus, Fig. 3216, is arranged as follows: The flask *C* is for holding the injection mass, and is connected with the pressure bottle *B* by a rubber tube. The manometer *M* is for measuring the pressure. The pulley *P* is fixed to the ceiling, and through it a rope passes which is attached to the can *a*, to the bottom of which is attached a rubber tube connected with the bottle *B*. The can *a* is filled with water which, upon raising the can, flows into *B*, compressing the air. The compressed air acting on the injecting mass, forces it through the rubber tube and cannula.

The amount of pressure can be regulated by the distance of the can *a* above the bottle *B*.

Some prefer to keep the animal warm during injection, but this is not necessary if the operator is rapid. A warming bath is shown in Fig. 3217. The animal after the cannula is tied in place is placed on the shelf *d* and the flask containing the injection mass on shelf *c* and the tank two-thirds filled with warm water.

In order to obtain the best injections it is advisable to relax the vessels by the use of a *vasodilator.* This may be done by the addition of amyl nitrite to the ether in anesthetizing or killing with pure amyl nitrite, or a little amyl nitrite may be added to the salt solution used to wash the vessels or to the injection mass just before using. One per cent. lactic acid, or a little morphine may be added to the injection mass. Mozejko recommends a saturated solution of peptonum siccum as it hinders coagulation.

For injecting pathological new formations, cold-flowing masses are to be preferred. The pressure employed must be moderate on account of the thinness of the walls of the blood-vessels. *Serres fines* (Fig. 3218) will be in great demand for checking the leakage

from the numerous lateral branches of the blood-vessels.

Injection of Lymphatics.—For injecting lymphatics the puncture method is the one chiefly employed. The puncture can be made from the cavity of a blood-vessel into the surrounding tissue, with the idea that a lymph vessel may be opened and that thus both sets of vessels may be injected. Or it may be made into the tissue and the injection made from this. The puncture must not be made at random, but in the direction in which small lymphatics are supposed to exist. The injection is made with a syringe fitted to the small cannula used for puncturing, and cold-flowing masses are to be used. If the extravasation is small and remains so, the injection is likely to succeed; but if the extravasation grows rapidly, the procedure is a failure and a new attempt is to be made.

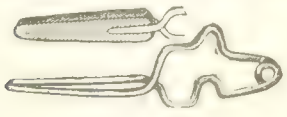

Fig. 3218.—Serres Fines.

Injection Masses.—These are either *cold* or *warm*.

Cold Masses.—These masses are liquid at the ordinary temperature and may be injected without warming. They set when the organs so injected are placed in alcohol or chromic acid solutions.

Fol's Metagelatin Mass.—Dissolve some gelatin in water, add a little ammonia and heat for several hours. *Metagelatin* is formed and the mass when cold does not solidify. This vehicle may be treated with any coloring substance and may be thinned by the addition of weak alcohol.

Tandler's Gold Gelatin Mass.—Soak 5 grams gelatin in 100 c.c. of water; this is then warmed and melted and Berlin blue added to color; then add 5 to 6 grams of potassium iodide gradually. This prevents the mass from coagulating down as low as 17° C. For fixation of organs so injected, five per cent. formalin is recommended.

Mayer (1910) uses 10 grams gelatin, 10 grams chloral hydrate and 100 c.c. water and colors to suit.

Mozejko (1910) recommends 10 per cent. of salicylate of sodium to prevent the setting of the gelatin.

Glycerin Masses.—Beale's Carmine Glycerin Mass.—Dissolve 5 grains of carmine in a little water containing 5 drops of ammonia and add ½ ounce of glycerin. Add gradually ½ ounce of glycerin containing 8 to 10 drops of acetic or hydrochloric acid, stirring. Test with litmus; the mixture must have a decidedly acid reaction. Then add ½ ounce of glycerin, 2 drams of alcohol and 6 drams of water.

Beale's Prussian Blue.—Dissolve 12 grains of potas. ferrocyanide in ½ ounce of water and a ½ ounce of glycerin. Add 1 dram of tincture of perchloride of iron to ½ ounce of water and ½ ounce of glycerin. Add the second to the first gradually and shake well. Then add 1 ounce of spirits of wine and 3 ounces of water gradually, shaking constantly. Injected specimens should be preserved in glycerin acidulated with 1 per cent. of acetic acid.

Thoma's Indigo-Carmine.—Dissolve 0.15 gram of sulpindigotate of sodium in 50 c.c. of distilled water. Filter and add 40 c.c. of glycerin and gradually 10 c.c. of a 10 per cent. solution of sodium chloride (filtered). To this 3 c.c. of a 1 per cent. solution of morphia may be added.

A *green* mass may be prepared by taking 80 c.c. of a sat. sol. of potas. arsenite and 50 c.c. of glycerin and mixing with 40 c.c. of sat. sol. of copper sulphate and 50 c.c. of glycerin.

Yellow Mass.—(1) Add 40 c.c. of a sat. sol. of cadmium sulphate to 50 c.c. of glycerin. (2) Add 30 c.c. of a sat. sol. of sodium sulphide to 50 c.c. of glycerin. Mix these solutions gradually, shaking thoroughly.

Aqueous Masses.—Berlin blue may be used in water 1 part to 20.

Mayer's Berlin Blue.—Dissolve 20 grams of yellow prussiate of potas. in 500 c.c. of water. Add to this 500 c.c. of water containing 10 c.c. of tincture of perchloride of iron. Allow to stand twenty-four hours. Decant and wash the deposit on a filter with distilled water until the washings come through dark blue and the deposit dissolves in one to two liters of water. Add a little acetic acid and preserve tissue in an acid medium.

Liquid Chinese ink may be used. The organs should be fixed after injection.

White of Egg (Joseph's).—Dilute filtered white of egg with one to five per cent. of carmin solution. This mass is coagulated with dilute nitric, chromic, or osmic acid solutions and remains transparent. It is especially recommended for Invertebrates.

Grosser, recommends *Indian ink in white of egg.*

Hamburger (1905) recommends 2 vols. of ink to 3 vols. of blood serum.

Bjeloussow's Gum Arabic Mass.—Make a syrupy solution of gum arabic and a sat. borax solution. Mix these so as to have in the mixture 1 part of borax and 2 parts of gum arabic. An almost insoluble mass results. This should be rubbed up in distilled water and strained through a close meshed cloth until free of lumps. The mass may be colored as desired. It coagulates and swells in alcohol. After injection the tissues are placed in alcohol and the swelling of the mass distends the vessels very much. It may be injected into living cold-blooded animals and will not flow from a cut vessel. The mass may easily be removed with dilute acetic acid.

Milk is recommended by *Fischer*. It flows readily, does not extravasate. After injection organs are placed for twenty-four hours in a mixture of formalin 75 parts, acetic acid 15 parts, and water 1,000 parts. After sectioning the sections may be stained with Sudan III of Scharlach R. but cannot be mounted in balsam.

Warm masses are solid at ordinary temperature and should be warmed to the body temperature when injected.

Warm-flowing Masses.—Robin's Gelatin Vehicle: One part of gelatin is soaked in seven, eight, nine, or ten parts of water, according to the consistence of the mass wanted, and when soft is melted on a water bath. This vehicle is then combined with any of the coloring masses just mentioned in the proportion of one part color to three parts vehicle. Filter through flannel before injecting.

Thiersch's Prussian Blue Mass: (1) A solution of gelatin, one part to two parts water; (2) saturated aqueous solution of ferrous sulphate; (3) saturated solution of potassium ferrocyanide; (4) saturated solution of oxalic acid.

Mix 12 c.c. of (2) with 30 c.c. of (1), at a temperature of 50° C. Mix at the same temperature 24 c.c. of (3) with 60 c.c. of (1), and add 24 c.c. of (4), with constant stirring. Add this solution to the solution of gelatin and iron; stir constantly until all the Prussian blue is precipitated. Heat on a water bath to 100° C., and filter through flannel.

Ranvier's Prussian Blue Mass: Prepare the Prussian blue as follows: Add to a saturated solution of ferrous sulphate, in water, a saturated aqueous solution of potassium ferrocyanide. Filter through a double filter of felt and paper. Wash with distilled water for several days, until the filtrate has a deep blue color. The Prussian blue has now become soluble. The precipitate is then dissolved in distilled water, and the solution kept in bottles until wanted.

Twenty-five parts of this solution are mixed with one part of gelatin. The gelatin is soaked for half an hour in water, and melted in the water it has absorbed, on a water bath. Heat the Prussian blue fluid to the same temperature, and mix with the

gelatin solution, gradually, under constant stirring. Filter through flannel.

The diffusion of the Berlin blue of the injection mass into the surrounding tissues is due not to the alkalinity of the tissues, but to the reducing action of the juices. To prevent this, Mozejko (1913) recommends that the injected tissues be fixed in an oxidizing agent as formalin. He uses formalin 10 c.c., alcohol (70) 90 c.c., pure nitric acid 5 c.c. After fixation (twenty-four hours) they are washed several times in seventy per cent. alcohol and may be prepared for imbedding.

Thiersch's Carmine Mass: Carmine 1 part, ammonia 1 part, water 3 parts. Dissolve and filter. Make a solution of gelatin in water, 1 to 2. Heat to 30° C. on a water bath, and add 1 part of carmine fluid for every 3 parts of gelatin solution. Then add acetic acid, drop by drop, stirring, until the free ammonia is used up. Inject at a temperature of 30° to 35° C.

Gerlach's Carmine Mass: Dissolve 5 grams of carmine in a mixture of 4 c.c. of water and 0.5 c.c. of ammonia. Allow it to stand several days, and mix with 8 parts of a solution of gelatin, 1 to 2. Filter and inject at a temperature of 40° C.

Ranvier's Carmine Mass: Rub up 2.5 grams carmine with a little water, and just enough ammonia to bring the carmine in solution. Soak 5 grams of gelatin in water, and melt on a water bath in the water it has absorbed. Add the carmine fluid slowly, with constant agitation. Neutralize the free ammonia by adding, drop by drop, a mixture of acetic acid and water, 1 to 2. Filter through flannel.

Thiersch's Yellow Mass: (1) One part of gelatin in 2 parts of water; (2) 1 part of neutral potassium chromate in 11 parts of water; (3) 1 part of plumbic nitrate in 11 parts of water. Mix 4 parts of (1) with 2 parts of (3). In another vessel mix 4 parts of (1) with 1 part of (2). Heat both mixtures to 30° C., and then combine, with constant stirring. Heat on a water bath to 90° C., and filter through flannel.

Thiersch's Transparent Green Mass: Combine the blue injection mass in various proportions with the yellow mass.

Frey's White Mass: Precipitate 125 to 185 c.c. of a cold-saturated, aqueous solution of barium chloride by adding sulphuric acid drop by drop. Allow the precipitate to settle for twenty-four hours, and decant the clear fluid. The remaining mucilaginous mass is mixed with an equal volume of strong gelatin solution.

Hartig's White Mass: Dissolve 125 grams of lead acetate in enough water to make the whole weigh 500 grams. Dissolve 95 grams of sodium carbonate in enough water to make the whole weigh 500 grams. One volume of each of the above solutions is mixed with two volumes of strong gelatin solution.

Fol's Dry Masses: Carmine—An indefinite quantity of ammonia is mixed with four times its volume of water, and carmine is added; after it has been standing an hour, with occasional shaking, no deposit should remain; then filter. Soak gelatin, in shreds, for two days in a sufficient quantity of the carmine solution. Then melt on a water bath with a small quantity of the solution. When melted add acetic acid until the color becomes blood red, taking care not to add an excess of acid. Too little acid is not a disadvantage; to much will cause a granular precipitate. Allow the mass to cool, and tie up in a piece of coarse net, and by pressing with the hands, under water acidulated with 0.1 per cent. acetic acid, force the mass out into vermicelli-like strings. These are placed in a sieve, washed well with running water, and dried on waxed paper.

Blue Mass.—The mass is prepared according to Thiersch's formula. After cooling press out into vermicelli, as above, and dry on waxed paper. For use, soak the vermicelli in water; when soft, melt with enough saturated solution of oxalic acid to render the mass fluid.

Brown and Black Masses.—Soak 50 grams of gelatin in 200 c.c. of water in which is dissolved 14 grams of sodium chloride. Melt on a water bath, and stir in briskly a solution of 30 grams of silver nitrate, dissolved in 100 c.c. of distilled water. This produces a fine-grained, white emulsion, which is allowed to cool. When cold, press out into vermicelli, as above, wash in running water, and by clear daylight mix with the following: Cold-saturated aqueous solution of potassic oxalate, 300 c.c.; cold-saturated aqueous solution of ferrous sulphate, 100 c.c. When the mass has become black throughout, wash in running water for several hours, and dry the vermicelli on waxed paper. The color of this mass, by transmitted light, is sepia-brown. If a gray-black tint is wanted, substitute 24 grams of potassium bromide for the sodium chloride in the first solution.

Hoyer's Yellow Gelatin Mass.—Mix equal volumes of concentrated gelatin solution and four per cent. silver nitrate solution and warm; add a small quantity of pyrogallic acid which reduces the silver rapidly. Then add five to ten per cent. by volume, of glycerin and two per cent. by weight, of chloral in a concentrated solution and strain. This mass is yellow in the capillaries and brown in the larger vessels.

The *ducts of glands* may be injected with gelatin masses to outline the course of these channels. A *triple injection* of organs may be carried out by means of red, blue, and yellow masses.

After injecting a warm mass, the organ or animal is placed in ice-water until it is thoroughly cold. Then the various organs may be removed, cut into blocks and fixed in eighty per cent. alcohol for twenty-four hours with several changes of alcohol. They are then ready for complete dehydration or may be stored in eighty per cent. alcohol for any length of time. Injected material may be infiltrated with paraffin or celloidin, but the latter is recommended, as at times the heat renders the gelatin mass brittle and it falls out of the larger vessels during sectioning and mounting.

Corrosion.—In order to study the normal cavities, distribution and arrangement of ducts and blood-vessels in an organ, a special mass is injected and the soft parts removed, thereby leaving a cast of the system injected. The mass must fuse at low temperature (water bath) and should not soften at the high temperature of the summer months. It should readily take color, should harden rapidly and uniformly and without cracking.

Huntington recommends the following mixture: Ozokerite 3 parts, paraffin (45° to 50° C.) 2 parts, white wax 1 part, rosin $\frac{1}{6}$ part, Venice turpentine about 2 drams to a quart of mass. The ozokerite, paraffin and wax are melted in water bath and when liquid the turpentine and powdered rosin are added. Some of the rosin does not dissolve, but is said to be taken up after the repeated heating of the mass.

E. A. Spitzka recommends ozokerit 2 parts, paraffin 2 parts, white wax 1 part. He states that the rosin does not incorporate readily and the turpentine does not permit the mass to harden as rapidly as it should.

For coloring it is advisable to use the various oil colors put up in tubes. These are added slowly to the melted mass with constant stirring. The various colors are *English vermilion, ultramarine blue, Prussian blue, purple lake, chrome green, chrome yellow, Chemnitz white,* etc.

A solid metal syringe of sufficient capacity for each injection should be utilized and the cannula should narrow abruptly at the point. The blood is removed from the organ by washing and milking the vessels and if fine injections are desired, it is best to float the object in warm water. As soon as the injection is completed, the organ is rapidly cooled.

The organs are then freed of any water in the vessels and placed in a dish and gradually surrounded and covered with fuming commercial hydrochloric acid; at first a glass plate should cover the dish which

should stand in the open air or under a chemical hood. The time required varies from several days to a week and as long as the acid fumes, it may be used again. Remnants of the organ may be removed by cautious washing of the cast. After drying the cast should receive a coat of shellac varnish applied as a spray. It may then be mounted upon a suitable stand.

Internal Ear (D. G. Metheny, 1914).—Select a good temporal bone and block off all openings of the middle ear, except the fenestra ovalis, with putty or clay. Make a wall of clay around the external auditory meatus and warm the bone. Pour melted Wood's metal into the middle ear. This will enter the internal ear through the fenestra ovalis. Keep the bone warm, tap it gently from time to time and rock it gently from side to side so as to allow the air bubbles to escape and to permit the metal to enter all the spaces of the labyrinth. When cold, the bulk of the bone may be removed with bone forceps and when the cast is approached, the mass containing it is placed in dilute nitric acid to dissolve away the remaining bone. The cast is then washed, dried, and mounted.

It is advisable to *x*-ray the bone after injection to see if the cast is perfect and if not, the bone should be warmed so as to melt the metal and then manipulated as above to remove the air that rendered the cast imperfect. This may be repeated if necessary.

Wood's Metal.—Tin 2 parts, lead 4, bismuth 5, cadmium 1. This melts at 66° C.

Lipowitz's Metal.—Tin 4 parts, lead 8, bismuth 15, cadmium 3. This melts at 60° C. and remains liquid to 55° C.

Reconstruction.—Sections very often do not give a clear idea of the form of small objects or their relations of parts to one another. For this reason reconstruction is resorted to and although these were at first utilized for the study and building up of fetuses and their organ systems, they are now applied to histology as well. In order to make a reconstruction, the object must be cut in serial sections and plates of a uniform thickness must be obtained. Several pieces of apparatus have been designed for the manufacture of these plates, but they can so readily be procured in a number of colors and of a uniform thickness that it is really a waste of time and effort to make them. Models can be made of any magnification. Outline of the magnified sections are drawn by means of a camera lucida or by the use of an Edinger projectoscope upon paper. The wax plates are then placed upon these drawings and cut out and superimposed upon one another until the series is completed. The rough model is then smoothed over with a warm spatula.

H. E. Radasch.

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Histones.—These are basic proteins that are probably intermediate between the strongly basic protamines and the true proteins. They have a nitrogen content varying from 16.5 to 19.8 per cent. and as a rule are richer in basic nitrogen and especially yield more arginine than other proteins. A peculiar protein substance was isolated from the red corpuscles of goose blood by Kossell and from its resemblance to peptone, in the old sense, he called it histone. There are a large number of extremely different bodies that at present are called histones, such for example as those obtained from nucleohistone, from hemoglobin (globin) from mackerel spermatozoa (scombron) from the cod fish (gadushistone) from the burbot (lotahistone) and from the sea-urchin (arbacin). Sulphur is usually present in histones, and they give a positive biuret test. On the other hand they usually yield only a faint Millon's reaction. The goose-blood histone gives the following reactions—a neutral salt-free solution fails to coagulate on boiling, it gives a precipitate with ammonia which is insoluble in an excess of the solvent, and it gives a precipitate with nitric acid which disappears on heating and reappears on cooling. Toward these three reactions the different histones behave differently and they therefore are undoubtedly bodies of varying composition.

Frank P. Underhill.

Histoplasma.—A protozoan parasite which is found in the endothelial cells in the liver, spleen, lungs, intestine, lymphatic glands, and in leucocytes. It causes a form of splenomegaly which resembles Indian Kala-azar, but the parasite differs from *Leishmania,* the cause of that disease, in possessing only a single chromatin mass. See *Protozoa.*

A. S. P.

Histoplasmosis.—*Definition.*—Histoplasmosis is an acute specific infection caused by *Histoplasma capsulatum,* Darling.

History.—This disease was first described by Darling in 1907, he having encountered it in the Canal Zone, Panama, in the years 1905 and 1906. He discovered it at autopsy. It has not yet been recognized clinically.

Etiology.—The *Histoplasma capsulatum* is a protozoon probably belonging to the Flagellidia. It is oviform or round, about three microns in diameter, and is surrounded by a clear, refractile, non-staining rim, in thickness about one-sixth of the diameter of the parasite. The structure is not homogenous but consists of a faintly staining substance and a deeply staining one; a clear space or spaces, and chromatin granules. These chromatin granules are generally single and eccentrically placed. The deeply staining substance is heaped up along one side or end and the vacuoles are contained within the faintly staining cytoplasm. The irregular disposition of the staining substance and the absence of the oval rod sharply differentiate this organism from the Leishman-Donovan body.

Pathology.—Two of the three cases encountered showed pseudogranulomata disseminated throughout the lungs. These when discrete measured two to three millimeters in diameter, were pearly white and dense, and were surrounded by areas of hemorrhage. The pseudogranuloma consists of broken-down alveolar walls and alveolar epithelial cells distended with parasites. Smears from these lesions do not contain tubercle bacilli.

The liver may be enlarged and show many small areas of necrosis. The spleen is greatly enlarged and has a firm yet friable pulp. The lymph nodes draining the liver and the spleen are enlarged, pale, yellow, and friable.

The histoplasma capsulatum is found in the endothelial cells lining blood- and lymph-vessels, in the areas of necrosis and pseudogranulomata, in the intestinal tract, spleen, liver, lymph nodes, and rib marrow.

Symptomatology.—The most striking clinical features are splenomegaly, emaciation, irregular remittent fever, anemia, and leukopenia.

Conclusion.—No treatment or prophylactic measures are known. Although no cases have been seen in Panama since 1906, it is probably to be found in unhygienic and less salubrious regions of tropical America not yet disturbed by the sanitarian.

L. B. B.

Hodder, Edward Mulberry.—One of the prominent physicians of Toronto, Canada, during the first

half of the nineteenth century. He was born in England, December 30, 1810, and received his medical education in London, under the guidance of Mr. Amesbury, a distinguished English surgeon. After he had ended his career as a student of medicine he visited Paris and Edinburgh, and settled as a practitioner, for short periods of time, first in London, next in St. Servan, France, then in Canada (1835), and finally a second time in St. Servan. In 1838 he returned to Canada and established himself in practice in the neighborhood of Queenstown, in the Niagara District. In 1843, after five years of marked professional success in the smaller locality, he removed to the city of Toronto, where he continued to live up to the time of his death.

In 1850 he established, in concert with Dr. James Bovell, the Upper Canada School of Medicine, which, later in the same year, became the medical department of Trinity College. For several years Dr. Hodder was a member of the Faculty of the Toronto School of Medicine, but, on the revival of his old school in 1870, he was appointed Dean of the Faculty, which position he held up to the time of his death. From 1852 to 1872 he was one of the staff of the Toronto General Hospital and of the Burnside Lying-in Hospital, and, at the time of his decease, was Senior Consulting Surgeon to both of these institutions, as well as to several others of like character. In 1862 he was chosen President of the Toronto Medico-Chirurgical Society, and in 1875 President of the Canada Medical Association. He died February 20, 1878, at the age of sixty-seven.

Dr. Hodder contributed to *The Practitioner* for July, 1873, an article on the transfusion of warm milk into the veins of patients in the later stages of Asiatic cholera. The experiment was tried in the hospital at Toronto during the cholera epidemic in 1849. (From data kindly furnished by Dr. A. Primrose of Toronto.) A. H. B.

Hodge, Hugh Lenox.—Father and son bore the same name, and both attained considerable celebrity, the former as a gynecologist and the latter as a general surgeon. The father was born in Philadelphia in 1796, and his name is still well known as that of the inventor of two very useful instruments—Hodge's obstetrical forceps and Hodge's pessary. The son was also born in Philadelphia, in 1836. In 1861 he was appointed Demonstrator of Surgery and Head Surgeon of the Surgical Clinic of the University of Pennsylvania. Nine years later he received the appointment of Prosector of Anatomy in the same institution. Dr. Hodge, senior, died February 26, 1873, and his son in 1881. The published writings of the latter, the majority of which will be found in *The American Journal of the Medical Sciences*, deal with a considerable variety of topics—hygiene, general surgery, gynecology, etc. The following are the titles of some of the more important of these essays: "Report on Cases in which Metallic Sutures were used;" "Tracheotomy in Cases of Pseudomembranous Croup;" "The Drainage of Abscesses and Wounds by Solid Metallic Probes;" "Excisions of the Hip, of the Knee, of the Elbow, and of the Wrist;" "Ovariotomy and a New Form of Trocar for the Evacuation of Ovarian and other Abdominal Fluids;" and "The Construction, Ventilation and Hygienic Management of Anatomical Rooms, etc." A. H. B.

Hodgkin, Thomas.—A descendant of a distinguished Quaker family, born at Tottenham, Middlesex, England, on August 17, 1798. He studied medicine at Guy's Hospital, London, in Paris, and in Edinburgh, at which place he received his degree in medicine in 1823. In 1825 he became licentiate of the College of Physicians, London, and was appointed curator and pathologist of the museum. He was also a member of the Senate of the University of London from its foundation in 1837 until his death. Hodgkin began his medical career as a physician in London, where he built up a very successful practice. As he grew older he gradually withdrew from active practice and devoted much time to travel and philanthropic work. While on a visit to Palestine and the East, he contracted dysentery and died at Jaffa on April 5, 1866.

Hodgkin wrote extensively on medical subjects, and in 1832 he published in the Transactions of the Royal Medical and Chirurgical Society, a report of a number of cases of contemporaneous enlargement of the spleen and lymphatic glands. It seems that he did not distinguish definitely several morbid conditions one from the other. In 1865 when Dr. Samuel Wilks pointed out that four of these conditions belonged to a type of disease which he himself had independently discovered, but in order to honor his predecessor as teacher of Pathology at Guy's Hospital, he gave this morbid condition the name of "Hodgkin's Disease." In 1828 he published an "Essay on Medical Education;" in 1832, "Hints Relative to the Cholera in London;" in 1836 his "Lectures on the Morbid Anatomy of the Serous and Mucous Membranes" were published and this work established his reputation as a member of the distinguished school of morbid anatomists at Guy's Hospital. In 1840 he wrote "The Means of Promoting and Preserving Health." E. L. J.

Hodgkin's Disease.—See *Pseudoleukemia*.

Hodgson, Joseph.—Born in Birmingham, England in 1788. He received his medical education at the Royal College of Surgeons and St. Bartholomew's Hospital, London. Here he began to practise, but in a short time removed to Birmingham, where he spent the greater part of his life. He was elected Surgeon to the General Dispensary, and in 1821 he was appointed Surgeon to the General Hospital. In 1824 he founded and became Surgeon to the Eye Infirmary. In 1849 he again returned to London, and was elected a member of the Council of the College. Later he became an Examiner in Surgery at the University of London, which honor he gave up to become one of the Examiners of the Royal College of Surgeons. In 1864, he was elected President of the College. He was also President of the Royal Medical and Chirurgical Society, and a Fellow of the Royal Society, of which he was Senior Fellow at the time of his death. His death occurred on February 7, 1869.

Hodgson was noted for his successful work as a lithotomist, and his name is associated chiefly with the condition produced by a dilatation of the arch of the aorta combined with insufficiency of the aortic valve and known as "Hodgson's Disease." Among his chief writings is his work on "Diseases of the Arteries and Veins," published in 1811, which won for him the Jacksonian Prize. During the early days of his practice in London he edited the *London Medical Review*. Many of his written contributions to medicine are contained in the Transactions of the Royal Medical and Chirurgical Society. E. L. J.

Hodgson's Disease.—See *Aorta, Diseases of*.

Hoffa, Albert J.—Born at Richmond, Cape of Good Hope, South Africa, March 31, 1859. He obtained his professional training at the Universities of Marburg and Freiburg (in Breisgau), and from 1883 to 1887 acted as assistant, first under Prof. Maas, and then under Prof. Schoenborn in the surgical clinic of the Julius Hospital at Würzburg, Bavaria. In 1897 he was appointed Professor Extraordinary of Surgery in the university of the latter city; but already

in 1886 he had established a private institute devoted to orthopedic surgery, gymnastic methods of treatment, and massage, and it was to this branch of surgical work that he from that time forward gave almost constant attention. His rich experience as an orthopedist is embodied in his treatise entitled "Lehrbuch der orthopädischen Chirurgie," 3rd edition, Stuttgart, 1898. He died in 1907.

Fig. 3219.—Albert J. Hoffa.

Besides the Lehrbuch already mentioned Hoffa published a large number of shorter treatises and essays. A few only of the more important of these published writings may here be mentioned: "Fracturen und Luxationen," 3rd edition, Würzburg, 1896; "Technik der Massage," 2nd edition, Stuttgart, 1897; "Die moderne Behandlung der angeborenen Hüftgelenksluxation," Munich, 1898. From 1892 onward, Hoffa acted as editor of the *Zeitschrift für orthopädische Chirurgie*.

A. H. B.

Hoffmann, Friedrich.—Born in Halle, on the Saale, Germany, February 19, 1660. In his early youth he received a most careful education. In 1678 he began his medical studies at the University of Jena, under the guidance of the celebrated professor George Wolfgang Wedel. In 1680 he received the degree of Doctor of Medicine. After practising his profession for seven years, with great success, in the city of Minden, he was called to fill the Chair of Medicine and Physics in the newly established University of Halle. In course of time he rose to be one of the greatest practitioners of medicine of the seventeenth century. Among the titles which were conferred upon him the following may be mentioned: Privy Councilor and First Physician of the King of Prussia; Dean of the University of Halle; Member of the Royal Society of London. He died November 12, 1742, after having given to the medical world a collection of his own writings of vast proportions and of inestimable value, the subjects of which cover every department of medical knowledge. Hoffmann's anodyne, spiritus ætheris compositus, bears the name of the subject of this sketch.

A. H. B.

Holarrhena.—*Conessi* or *Tellicherry Bark.* The bark of *H. antidysenterica* Wall. (fam. *Apocynaceæ*), a woody plant of India. It is one of several plants whose barks have gone under the name of "Kura" or "Kuda" in India. The active constituent is an alkaloid which has been called *Wrightine* ("conessine"), and there is some doubt about its identity with what has been regarded as the same from other sources. It is contained also in the seeds. The bark appears to be a carminative and intestinal astringent, and the alkaloid somewhat antiperiodic. It is very largely used in native practice in India as an antidysenteric, and has been considerably so used in Europe. Reports as to its efficacy are discordant, but its use has declined. An aqueous extract is used in three-grain doses.

Henry H. Rusby.

Holly.—This is a name given to various species of the genus Ilex, especially *I. aquifolium* (L.), the English or European holly. A number of the species (see *Cassina* and *Maté*) contain caffeine and are used accordingly. The leaves of European holly were formerly largely employed in catarrhal affections. They possess mild diaphoretic properties. They contain *ilicic acid* and *ilicin*, neither of which is accurately known. *Ilex verticillata* (L), A. Gray the winterberry, false, black, or striped alder, is a shrub or small tree which abounds in swamps of eastern North America. Its bark is employed as an intestinal astringent and tonic. Before the advent of quinine, it was a largely employed antiperiodic.

H. H. Rusby.

Holmes, Oliver Wendell.—Born in Cambridge, Mass., August 29, 1809. He obtained the degree of M. D. from the Harvard Medical School in 1836. After several years of foreign study he settled in Boston, but gave up the practice of his profession about 1849. In 1847, on the resignation of Dr. John C. Warren, he was elected Parkman Professor of Anatomy and Physiology in the Harvard Medical School. Later a separate Chair of Physiology was

Fig. 3220.—Oliver Wendell Holmes.

established, but Holmes continued to hold that of Anatomy until 1882. His death occurred October 7, 1894.

During the earlier years of his professional career, Holmes published a number of essays and short articles on topics of a medical nature, and in 1883 these were reissued in a single volume entitled "Medical Essays." Had he chosen to remain in medicine rather than to devote himself to literature there can be no doubt that he would have won a place among the greatest physicians of the nineteenth century. His essay on "The Contagiousness of Puerperal Fever," in which he revealed, with the clairvoyance of the poet, the true nature of this murderous disease should place him among the immortals of the healing art. The paper was read before the Boston Society for Medical Improvement and was published in the *New England Quarterly Journal of Medicine and Surgery* for April, 1843, some years before Semmelweiss, to whom the credit for the discovery is usually given, proclaimed his theory. Holmes' attention was first directed to the subject by an incident informally related by a member at one of the meetings of the Boston Society

for Medical Improvement. The narrator told of a physician who had made a postmortem examination of the body of a puerperal fever patient, and had himself died in less than a week, apparently in consequence of a wound received at the examination. In the meantime, he had attended several women in confinement, all of whom were said to have been attacked with puerperal fever. The one who related the incident failed to see its significance, but the quick perception of Holmes grasped it, and he set about to collect the evidence upon which to base his theory of puerperal infection. There was an abundance of material, and in the essay which followed there was an array of facts that should have left no doubt in the mind of the reader that the disease was communicable. But, like all revolutionary discoveries, it was received with incredulity, and the theory was actively opposed by the leading obstetricians of the day. The conclusion of this paper and the rules which the author proposed for preventing the spread of puerperal fever were:

"(1) A physician holding himself in readiness to attend cases of midwifery should never take any active part in the postmortem examination of cases of puerperal fever. (2) If a physician is present at such autopsies, he should use thorough ablution, change every article of dress, and allow twenty-four hours or more to elapse before attending to any case of midwifery. It may be well to extend the same caution to cases of simple peritonitis. (3) Similar precautions should be taken after the autopsy or surgical treatment of cases of erysipelas, if the physician is obliged to unite such offices with his obstetrical duties, which is in the highest degree inexpedient. (4) On the occurrence of a single case of puerperal fever in his practice, the physician is bound to consider the next female he attends in labor, unless some weeks at least have elapsed, as in danger of being infected by him, and it is his duty to take every precaution to diminish her risk of disease and death. (5) If within a short period two cases of puerperal fever happen close to each other, in the practice of the same physician, the disease not existing or prevailing in the neighborhood, he would do wisely to relinquish his obstetrical practice for at least one month, and endeavor to free himself by every available means from any noxious influence he may carry about with him. (6) The occurrence of three or more closely connected cases, in the practice of one individual, no others existing in the neighborhood, and no other sufficient cause being alleged for the coincidence, is *prima facie* evidence that he is the vehicle of contagion. (7) It is the duty of the physician to take every precaution that the disease shall not be introduced by nurses or other assistants, by making proper inquiries concerning them and giving timely warning of every suspected source of danger. (8) Whatever indulgence may have been granted to those who have heretofore been the ignorant cause of so much misery, the time has come when the existence of a private pestilence in the sphere of a single physician should be looked upon not as a misfortune but as a crime, and in the knowledge of such occurrences the duties of the practitioner to his profession should give way to his paramount duties to society."

The limits of this biographical sketch will not allow of a discussion of the literary work of this man of genius, but one can claim with Stone that his "large and exquisite contributions to literature, not medical, no less reflect their splendor upon the profession."

T. L. S.

Holmgrén, Alarik Frithiof.—Born at Asen, Sweden, October 22, 1831. He studied medicine in Upsala, and received his doctor's degree from the university of that city in 1861. In the same year he was made Adjunct Professor of the Theory and Practice of Medicine in the university. During the years 1861–1864 he devoted himself to experimental physiology, under the teaching of Bruecke, Ludwig, and DuBois-Reymond, in preparation for his acceptance of the professorship of physiology in the University of Upsala. He assumed the duties of this chair in 1864, and at the same time superintended the construction and equipment of a physiological laboratory, the first one established in Sweden. In 1869 he worked under Helmholtz in Heidelberg, and afterward visited the laboratories of Italian universities, of Paris, and of London. He died August 14, 1897.

Holmgren is known chiefly on account of his work in investigating the subject of color-blindness, especially in its practical relations to navigation and the running of railway trains. His treatise on this subject is entitled: "Die Farbenblindheit in ihren Beziehungen zu den Eisenbahnen und der Marine," Leipzig, 1878. The test for color perception by means of skeins of variously colored worsteds, which he devised, is one of the best-known and most popular methods in use to-day. A. H. B.

Holocaine, para-diethoxy-ethenyl-diphenyl-amidin hydrochloride $[(C_6H_4.O.C_2H_5)_2.NH.C.CH_3.N.HCl]$, is a condensation product of phenacetin and paraphenetidin. It crystallizes in bitter, white needles which are freely soluble in alcohol and ether and in forty-five parts of water. It is not affected by a temperature of 212° F. (100° C.). With alkalies it is decomposed and precipitated, the presence of a calcium salt in the water used for solution being sufficient to produce turbidity. It attacks any free alkali in glass; so, to prevent precipitation, the glass container should previously be boiled with acid.

Holocaine has a deleterious effect on protoplasm, as in 0.1-per-cent. solution it stops fermentation and putrefaction, in 0.5-per-cent. solution it arrests the development of germs, and in one per cent. it stops ameboid movements and kills most microorganisms. Hence the solutions are sterile, though if desired they may be boiled without harm. Holocaine paralyzes the sensory nerve endings, and is a local anesthetic of great power. It is claimed by Hotz, Wurdemann, Knapp, Jackson, and others to be quite as anesthetic in the eye as cocaine, quicker in its action, and its effect more lasting, and as it is more penetrating the iris is more anesthetized. It does not dry the cornea, increase intraocular tension, or influence the pupil or accommodation. Neither does it constrict the vessels, and, on the contrary, it tends to produce slight hyperemia. This comparison with cocaine can be well demonstrated by dropping cocaine solution in one eye, and holocaine solution in the other eye of the same patient. The amount used for eye work is two to five drops of one-per-cent. solution, and in one-half to two minutes this produces anesthesia lasting ten to fifteen minutes. Derby and Knapp recommend it for the removal of foreign bodies as it leaves so little effect on the eye. They also find it the most serviceable drug in corneal ulcers of microbic origin, and in purulent ophthalmitis. Holocaine cannot be used like cocaine by hypodermic for local anesthesia, as it is much more toxic, its action in overdose resembling that of strychnine (Heinz). W. A. Bastedo.
R. J. E. Scott.

Holothyrus.—A genus of mites. *H. coccinella* is found on ducks and geese in Mauritius. It often attacks man, particularly children, and causes severe swelling and itching. Sometimes it attacks the lips and tongue. See *Arachnida.* A. S. P.

Holotricha.—An order of protozoans. The body is covered with cilia of uniform size and structure. Some of these animals live as internal parasites or commensals. See *Protozoa.* A. S. P.

Homalomyia.—*Fannia.* A genus of flies. *F. canicularis* is commonly found in houses in Europe and America. The larvæ usually live in vegetables and frequently pass into the human intestine where they may cause serious and prolonged trouble. Infections have also been reported in the urinary tract. See *Insects, parasitic.* A. S. P.

Homatropine.—Atropine and hyoscyamine when decomposed break up into tropic acid and tropine. The latter when combined with mandelic acid forms homatropine; mandelic acid being the product of the action of hydrochloric acid on amygdalin. Homatropine combines with acids to form salts; the hydrobromide, hydrochloride, and salicylate are those most employed. The hydrobromide is official in the United States Pharmacopœia as *Homatropinæ Hydrobromidum*. Pure homatropine is almost insoluble in water but is slightly soluble in oil and vaseline. A two-per-cent. solution in oil and gelatin discs are prepared for ophthalmic work. The advantage claimed for the solution in oil is that it is not so readily washed from the eyes by the tears. Homatropine is weaker in its action than atropine and when administered internally acts in much the same manner as does the more common alkaloid. It is said to differ from the latter in causing a slowing of the pulse, but this is not marked when large doses are administered. The dose of the hydrobromide as given is gr. $\frac{1}{100}$—$\frac{1}{30}$ (0.0006—0.002). It has been recommended for use in all conditions in which atropine is indicated, particularly in the night sweats of phthisis. It, however, has not been much employed, as it has not proved so trustworthy as atropine.

Homatropine is almost entirely employed as a mydriatic in ophthalmic work. Its action is much less intense than that of atropine, but it dilates the pupil and paralyzes the ciliary muscle almost as rapidly, and its effects pass off in a much shorter time. The pupil begins to dilate in ten or twenty minutes and paralysis of accommodation is complete in about one hour. In from twelve to twenty-four hours its action is quite recovered from. A one or two per cent. solution is used.

BEAUMONT SMALL.
R. J. E. SCOTT.

Homburg.—This popular watering-place is situated in the Rhine land, ten miles north of Frankfort-on-the-Maine. It is reached from Paris, from which it is 477 miles distant, direct by rail, or viâ Cologne and the Rhine.

The town is built on a spur of the Taunus Mountains at an elevation of 643 feet above sea level. Its natural situation is not picturesque, but art has done much in the way of beautiful pleasure grounds, extensive parks, and promenades. It contains 9,278 inhabitants and is annually visited by 12,000 persons, forty per cent. of whom are said to be foreigners, including a large number of English. Homburg was one of the favorite resorts of the late King of England.

The mineral springs and sanatoria are in a large Kurpark which extends toward the northeast into the forests of the foothills of the Taunus.

The climate is that of Central Germany, mild and rather dry, the average yearly temperature being 47.5° F.; and for summer, May 56.3° F.; June, 66.2° F.; July, 65.6° F.; August, 66.5° F.; September 56.3° F. The yearly rainfall is 26.6 inches. The season extends from May to the end of September.

The waters of Homburg are saline-chalybeate, and are derived from the Taunus schist and quartzite. The principal constituents are the chlorides of sodium, calcium, magnesium, and lithium; the carbonates of iron and calcium, and free carbonic acid. Unlike the waters of Ems, they are cool and have to be artificially heated when used for baths. They come under the general classification of common salt or muriated waters and are similar to those at Wiesbaden, Kissingen, Baden-Baden, Kreuznach, and Nauheim.

There are seven springs, as follows, with their temperatures: Elizabethbrunnen, 51.1° F.; Ludwigbrunnen, 53.4° F.; Louisenbrunnen, 52.1° F.; Landgrafenbrunnen, 51.8° F.; Kaiserbrunnen, 52.9° F.; Stahlbrunnen, 51.8° F.; Soolsprudel, 51.8° F.

The Louisenbrunnen and Stahlbrunnen are distinguished by their excess of carbonate of iron. All these springs are used for drinking except the Soolsprudel and Landgrafenbrunnen.

The Ludwigbrunnen, Kaiserbrunnen, Louisenbrunnen, and Soolsprudel are used for bathing, the water being warmed by hot steam chambers at the bottom of the baths, with the least possible escape of carbonic acid gas. The waters of the Ludwigbrunnen are used for inhaling. All the springs are the property of the town of Homburg, which has erected the various bath-houses; the Kaiserbrunnen with sixty bathrooms, and two piscinæ for natural carbonic-acid salt baths, mud baths, and mineral, and fresh-water baths; Kurhausbad with thirty-three bathrooms. In the former 26,147 baths were given in 1899, and in the latter over 7,000. In the Kaiser Wilhelm's bath are inhalations with spray produced by compressed air.

Besides the mud baths mentioned there are pine-needle, electric, medicated, and steam baths; and there are also good facilities for Swedish gymnastics and massage, as well as for the milk and whey treatment.

The chief center for visitors is the Kurhaus, containing handsome apartments, reading-room, etc., with a terrace partly covered with glass, and corridors, affording a sheltered promenade. At the back of this Kurhaus extend the beautiful pleasure grounds with a palm-house, orangery, and well-kept flower beds.

The town contains water-works, a sewerage plant with facilities for filtration, and a steam disinfecting apparatus.

Therapeutics.—When these waters are taken internally they gently stimulate the gastric and intestinal mucous membrane, at the same time rendering the contents of the bowels more fluid; they are therefore beneficial in catarrhal affections of the alimentary tract. Taken in small quantities they are constipating, but laxative in larger quantities. They help to increase the general nutrition, according to Weber, by their action in aiding the digestion of albuminous materials.

According to the same authority, they often increase the weight in thin persons, and for such cases are preferable to the alkaline-sulphated waters.

They are also beneficial in catarrhal affections of the respiratory tract; in gout, uric-acid diathesis, obesity, hemorrhoids, diseases of women, heart diseases, and malaria. Those springs containing iron are useful in cases of anemia and chlorosis.

Fifty-five thousand liter bottles of these waters are yearly exported.

EDWARD O. OTIS.

Homeopathy.—Homeopathy is not a system of medicine. It does not replace surgery, hygiene, biological medicine, chemical antidote, physical therapeutics, or even the physiological dosage of the modern physician. It is but one of many methods of treating sickness. It admits the possibility of eliminating, by other means, the evidence of illness. Properly understood, homeopathy is nothing more than a method of therapeutic application. Its one and only demand for recognition is its peculiar way of determining the remedy for the removal of the symptoms of disease. The size of the dose prescribed and the repetition of the remedy have little to do with homeopathy. Whether a given prescription is homeopathic or not depends purely and simply upon the means of its selection. Homeopathy, then, is a method of therapeutic procedure.

The homeopathic method of treatment is founded on this hypothesis: The symptoms of disease, as met by the practitioner, may be removed by the administration of a remedy which is capable of producing similar symptoms when administered to a healthy person. This doctrine was expressed by its

founder in the Latin phrase, *Similia similibus curentur*, and in the German, *Heile durch Symptomenaehnlichkeit;* the practice of Homeopathy accords with the rule thus expressed.

It is an unfortunate fact that, in spite of a hundred years of practical use of this method, there is still much misunderstanding of its exact place in the practice of medicine. It is the purpose of this article to attempt, in a brief way, to show not only what homeopathy is, but also how it may be useful to the non-homeopathic graduate.

No man has practised medicine for any considerable time without meeting diseases which seem incapable of removal by ordinary means. Perhaps the pathology is not understood; the symptoms are so obscure that a diagnosis is impossible; the usual treatment has met with no satisfactory result. What then can be done? To the average physician expectant treatment and experiment are all that are left. In such a case, homeopathy offers hope of cure. It is better, certainly, than the expectant method, because the physician is at least doing something for the patient. It is superior to experiment, because it has the merit of some recorded evidence of usefulness.

Granted, then, that homeopathy will be given a trial, how should the physician proceed? He must first elicit from the patient all his peculiar and abnormal symptoms. It matters not whether these symptoms relate to the particular organ diseased, or whether they are remote from that part of the body. It is desirable to gather the "totality of the symptoms," all the evidences of the patient's departure from health. Special attention is paid to the conditions that produce relief or increase of suffering, inquiry being made as to the effects of heat and cold, of rest and motion, of excitement and calm, of specific items of food and drink, of the time and particulars of aggravation or amelioration. Systematic examination and questioning are instituted to discover peculiar and unusual symptoms.

These carefully gathered symptoms may be set down as the outward and visible, or inward and functional, evidence of the patient's disorder. They are now to be compared with the recorded "provings" of the drugs.

In making up the homeopathic materia medica, every possible source of information has been visited. Poisonings, accidental or intentional, pharmacological tests, animal experiments, postmortem findings—all these records have been studied. In addition, careful provings are made by administering to the healthy person the chosen drugs, in varying strengths, to determine their power to modify or disturb the functions of the body. Subjective symptoms are recorded with the same care as are the objective signs of departure from health. These many symptoms, gathered from every possible place of information, are grouped together to make up the so-called "Materia Medica Pura."

To make clear exactly the scheme employed in preparing the homeopathic materia medica, let us take a single remedy and see how its field of usefulness is determined. For instance, it may be *bryonia alba*,a drug hardly more than mentioned in the United States Pharmacopœia, and rarely prescribed by physicians unfamiliar with homeopathy.

The poisonings with and provings of this drug show it to have three chief centers of conspicuous effect. These are as follows:

The serous membranes, producing inflammation and effusion.

The mucous membranes, resulting in arrest of the secretions.

The muscles, causing irritation and even inflammation.

This general picture of bryonia prepares one to understand the multitude of symptoms produced by the drug, for instance, sharp, stitching pains in the chest or in the muscles; constipation, with stools dry and hard as if burnt; congestive headache, feeling as though the skull would burst open; aggravation of all symptoms from motion. The reason for and explanation of each of these symptoms can be found in the general outline of the "sphere of action" of the drug.

Unfortunately, disease, as it is met in practice, does not present clear-cut indications for this or that remedy. It necessitates us, therefore, to study our patient carefully, in order that we may be led to the selection of the curative drug. Stumbling upon an obscure and, at first thought, insignificant symptom, may make plain at once that Bryonia is the remedy. Determining the remedy in this way is analogous to arriving at a diagnosis by virtue of a single symptom. For instance, the symptoms of a given eye condition may leave one at a loss to decide whether the case be one of iritis or glaucoma; the discovery of increased intraocular tension decides the diagnosis. Differentiations between remedies are difficult to make, but careful comparisons must lead the informed student to the indicated drug. In pneumonia, for instance, one may hesitate between belladonna and bryonia, both producing inflammation. The exudate would at once determine that the disease had passed the stage where the former remedy could be of value, and would decide the indication for bryonia.

It will be understood, of course, that in the brief compass of this article one cannot go into the minute details of a system that must be carried out with scientific exactness to insure success. It is the desire of the writer, however, to bring out some of the things that seem important enough to demand the serious consideration of every practitioner. The average physician pays little attention to the moods and mental condition of his patient. He is inclined to scoff at the possible remedial usefulness of drugs for the removal of purely subjective symptoms. He knows, as does every layman, that the taking of this drug or that may be followed by certain mental disturbances; it may be the exhilaration of alcohol, or the sedation of morphine. To make use of remedies, however, to restore normal function to a disturbed mind is rarely undertaken. The homeopathist has faith in the power of his remedies to modify and control subjective symptoms. While such observations may not be capable of mathematical demonstration, yet the repeated verification of these clinical experiences must go far toward satisfactory proof of their reliability.

In collecting material for the materia medica, therefore, no symptom, objective or subjective, repeatedly occurring in the provers, has been disregarded. While much chaff has been included, doubtless, yet the grains of fact are so many that we feel no therapeutist can afford to disregard the virtues of our literature. It is for the practitioner to determine for himself what is reliable and what unreliable in the collection of symptoms known as the materia medica pura. The one central and essential fact of the system is that the remedy chosen must correspond in similarity to the symptoms of the patient. Its possibility of usefulness is destroyed if the drug be administered because the patient has a definite pathological condition. The prescriber must forget the name of the disease, and choose the remedy for the one and only reason that it is the "similimum" for that particular case.

Let it not be supposed, however, that the homeopathic physician looks askance upon the advances of general medicine. The sputum examination, for instance, in the diagnosis of throat and lung diseases, is given the same importance in the homeopathic world that it receives elsewhere. The most radical opponent of homeopathy would not say that in the choice of a drug the presence or absence of the germ would influence his selection of a curative remedy.

It would simply decide the question of climate or the general disposition of the patient. It means at least that much to the homeopathic prescriber. The laboratory methods of science receive the same patronage and the same encouragement in the homeopathic school as elsewhere. In surgery, in gynecology, in ophthalmology, the same careful technique, the same skill, the same methods are everywhere employed. No one claims that the results of surgery in other schools are superior to those gained by the homeopathic operator. The American Institute of Homeopathy has officially decreed that "a homeopathic physician is one who adds to his knowledge of medicine a special knowledge of homeopathic therapeutics. All that pertains to the great field of medicine is his by tradition, by inheritance, by right."

It has been stated already that the size of the dose has nothing to do with homeopathy. Whether one give "a smell or a tub-full" the use of the remedy may be considered homeopathic, provided it is prescribed in accordance with the fundamental hypothesis of the system. As a matter of practice, however, homeopathic physicians usually employ "dilutions" or "attenuations," known familiarly as "potencies." In what is known as the "decimal" system, one grain or minim of the chosen drug is diluted with nine parts of alcohol, or triturated with nine parts of some inert substance, like sugar of milk. This makes what is called the "first potency," indicated by the symbol "1x." To make the second potency, one part of the first is treated with nine parts of the vehicle. The third is made in a similar manner from the second, etc., etc. It will be seen that each succeeding potency is one-tenth the strength of the preceding one. While there are many so-called "high potency" homeopaths, it is probable that most homeopathic physicians employ the third potency, each dose representing one one-thousandth of a grain of the drug. With a remedy prescribed for symptoms similar to its physiological action, it must follow that too large a dose would produce an aggravation of the disease. For this reason, it is desirable to prescribe a dosage short of one producing actual physiological effect. It is aimed to get what the homeopathist calls the "dynamic" effect of the drug, in contradistinction to its physiological or poisonous effect.

"The proof of the pudding is in the eating." The practical value of homeopathy lies in its results. What are these? Perhaps it is not within the scope of this article to enumerate them. It is the belief of the writer, however, that the duration of diseases, concerning which we have pretty accurate knowledge of their natural history, can be materially shortened and the suffering of the patient alleviated. This is a dogmatic statement and proves nothing, of course. But, aside from individual conviction, is not a method of therapeutic application that has withstood a century of criticism worthy of careful consideration? Since homeopathy is not intended to displace causal therapeutics or remedial measures of known value, is it not incumbent upon the well-informed and conscientious physician to study its possible virtues? This writer has seen glaucoma, acute infections of the eye, and other definite and unmistakable diseases disappear under this system of treatment. Its useful application in every class of affections has been testified to by hundreds of practitioners. Perhaps its advocates have appeared to claim too much, or have failed to make clear its exact place in medical practice. When it is understood, however, that homeopathy is but a method of therapeutic procedure, and makes no pretense to being a system of medicine, its merits may become better known and more commonly applied in practice.

"Hahnemann placed homeopathy squarely on two facts or two classes of facts; on one side, the facts of disease, the subjective and objective symptoms of the naturally diseased patient; on the other side, the facts of the remedy, the subjective and objective symptoms of the drug diseased patient. These two classes of facts he made to serve for the premises of a scientific therapeutic application. He directed to cure curable medical constitutional diseases by symptom-similarity, by the similitude of the natural and the drug disease effects, and this method of symptom-similarity he denominated homeopathy. This is all that homeopathy is. It is a plain scientific method, and just because it is this and nothing more, it carries with it all the elements of historic permanency. To speak broadly, but none the less exactly, the sciences of pathology and pharmacology are the premises. Homeopathy, then, is "the method by which the facts of the sciences of pathology and pharmacology are brought into correspondence for the purpose of cure when cure is possible." The colleges of homeopathy teach all the fundamental sciences, present all the facts and theories of general medicine, and in addition, give the student detailed knowledge of the materia medica pura. The hospitals under homeopathic control apply in a practical way the didactic teachings of the colleges. Both the colleges and the hospitals recognize the limitations of homeopathy and confine its application to its proper sphere. Thus employed homeopathy has a place in medical practice that cannot be disregarded.

ROYAL S. COPELAND.

Honey.—See *Mel.*

Honthin is a tasteless and odorless compound of tannin, keratin, and albumin, which is said to pass through the stomach unchanged, and to be slowly separated into its constituents in the intestine. It is an intestinal astringent, is insoluble in water, and may be given alone or with chalk mixture for diarrhea or intestinal fermentation (Reichelt, Frieser).

W. A. BASTEDO.
R. J. E. SCOTT.

Hoof and Mouth Disease. *See Foot and Mouth Disease.*

Hookworm.—See *Uncinaria, under Nematoda.*

Hookworm Disease.—Ankylostomiasis, Miner's Anemia, Uncinariasis, Negro consumption, Dochmiasis, Egyptian and Tropical Chlorosis, Tunnel disease, Geophagia, Allotriophagia. A toxemia resulting in a progressive anemia, caused by *Ankylostoma duodenale* and *Necator americanus*. It is prevalent in most tropical countries and in many mines. Infection may take place through the mouth or skin. See *Nematoda* and *Uncinariasis*. A. S. P.

Hoppe-Seyler, Ernst Felix Immanuel.—Born at Freiburg a. d. U., December 26, 1825. He pursued his medical studies at the universities of Halle, Leipzig, Prague, Vienna, and Berlin, and received the degree of Doctor of Medicine from the latter university in 1850. During the years 1852–1854 he devoted considerable time to research work in the department of physiological chemistry. In 1856 he became an assistant in the Pathological Institute, under Virchow, and was assigned to work in pathological chemistry. In 1861 he was made Professor of Applied Chemistry in the University of Tübingen; and finally, in 1872, he was called to fill the Chair of Physiological Chemistry in Strassburg, a position which he held up to the end of his life. He died August 10, 1895.

Hoppe-Seyler is entitled to be considered the founder of modern physiological chemistry. The number of his original investigations in this department of medical science is very large; and the influence which he exerted as a teacher is also very great. The majority of the professors of physiological chem-

istry in the universities of Germany and very many of those in foreign universities received their training as teachers under Hoppe-Seyler. Of his published writings only a few of the more important ones may here be enumerated: "Handbuch der physiologisch- und pathologisch-chemischen Analyse," Berlin, 1858 (5th edition, 1883); "Physiologische Chemie," 1877–1881; "Medicinisch-chemische Untersuchungen," 1866–1871; and "Zeitschrift für physiologische Chemie," 1877–1894. A. H. B.

Hops.—See *Humulus.*

Hordein is a protein obtained from barley and is especially characterized by yielding a large quantity of protein (α-pyrolidine carboxylic acid) on hydrolysis. F. P. U.

Horehound.—See *Marrubium.*

Hormones.—This term is applied to those substances which excite glands to secretion. The most typical case of a hormone is that in connection with the pancreas where the absorption of secretin in the intestine calls forth a flow of pancreatic juice. Secretion by a hormone is regarded as a chemical secretion, as distinct from one induced by the influence of the nervous system. F. P. U.

Horner, William Edmonds.—Born in Warrenton, Virginia, June 3, 1793. He received the degree of Doctor of Medicine from the University of Pennsylvania in 1814. In 1815 he settled in Philadelphia. He was very fond of the study of anatomy, and he dissected with so much skill and neatness that Dr. Casper Wistar, who was at that time Professor of Anatomy in the University of Pennsylvania, arranged with him, in 1816, to become his assistant and to prepare the subjects for demonstration. After the death of Wistar, in 1818, Horner became the assistant of Dr. Physick. In recognition of the manner in which he had done the anatomical work assigned to his care the authorities made him (1820) Adjunct Professor of Anatomy; and in 1831, when Physick resigned, he was chosen as the latter's successor. For over twenty years from this time he continued to hold the Chair of Anatomy; and during this period he made many and most valuable additions to the Anatomical Museum which had been founded by Wistar. The trustees, recognizing the exceptional character of these gifts and the great generosity of the donor, gave the museum the name of the "Wistar and Horner Museum." Horner died in Philadelphia, March 13, 1853.

Of Horner's published writings the three most important ones are these: "Special Anatomy and Histology" (8 editions between 1826 and 1851); "United States Dissector" (5 editions up to 1856); and "Anatomical Atlas." A. H. B.

Hornet.—Certain species of hymenopterous insects belonging to the genus *Vespa.* The stings of some cause pain and even more serious trouble, such as swelling, abdominal pain, and unconsciousness. See *Insects, poisonous.* A. S. P.

Horseradish.—See *Cochlearia.*

Hosack, David.—Born in New York City, August 31, 1769. He received his degree of Doctor of Medicine in 1791, from the University of Pennsylvania. In 1792 he began the practice of his profession in his native city. He soon, however, decided to visit London and Edinburgh, and in 1793 he entered St. Bartholomew's Hospital as a pupil of Sir James Earle, the son-in-law of and successor to the celebrated John Hunter. In addition to the study of surgery he spent several hours every day in examining the various genera and species to be found in the botanic garden of William Curtis, author of the "Flora Londinensis," and also, once a week, accompanied him in an excursion, for botanizing purposes, to the different parts of the country in the vicinity of London. During the winter season he devoted himself to anatomical dissections, to chemistry and materia medica, and to mineralogy. In 1794 he returned to New York and resumed practice. In 1795 he was appointed to the Professorship of Botany in Columbia College,

Fig. 3221.—David Hosack.

and it was also about this time that he was taken into partnership by Dr. Samuel Bard, one of the most eminent of New York's physicians. In 1797 Dr. Hosack was appointed to the Chair of Materia Medica in Columbia College, in addition to that of botany which he already held. In 1807, when the College of Physicians and Surgeons was established as an independent organization, he gave up these two chairs and was chosen Professor of Surgery and Midwifery in the new institution. After a short time, however, he relinquished this chair for that of the theory and practice of physic and clinical medicine. General Alexander Hamilton remained one of his closest friends and it was Hosack who accompanied him to the fatal field, when he fell in his duel with Aaron Burr.

According to the Memoir of Dr. David Hosack, written by his son, Dr. A. E. Hosack, he performed at the Almshouse Hospital "many important surgical operations, done for the first time in America; among which may be cited that of tying the femoral artery at the upper third of the thigh, after the manner recommended by Scarpa. This operation was performed by Dr. Hosack as early as 1808. He tied the same artery several times afterward for aneurysm. He introduced, as early as 1795, in American surgery, the operation for hydrocele by injection. He also contributed several valuable essays on surgical subjects, and cases, such as, 'Observations on Glossitis' 'Cases of Tetanus Cured by Wine, Spirits, and Brandy'; 'Observations on Tic Douloureux'; 'Cases of Anthrax'; 'Observations on Hemorrhage, and the Removal of Scirrhous Tumors of the Breast.'"

Hosack's death occurred December 22, 1835. (*Stone.*) A. H. B.

Hospital Construction and Equipment.—There are a good many well-informed persons, architects, hospital administrators, physicians, and interested laymen, who think that hospital architecture is very well standardized—indeed that the hospital which is to stand all the tests for a time far into the future, has already been designed and built. The trouble about the standard is that so few persons agree as to what the type is, so many opinions are

based on inadequate appraisal of the purposes of the modern hospital and a too general feeling that a hospital adequate for one set of conditions will suffice for all.

The architect has rather stopped short in his idealization when he has taken care of the "fresh air" problem, and the fetish of the "open air treatment"; the rest of his talents are expended on his own ideals as to "beauty of form" and other strictly architectural demands.

The physician and surgeon, greatly hampered by their limitations in knowledge of architecture, and concerning the broad administrative purposes of the hospital, think only in terms of their individual needs, for the care of their own patients; while the hospital administrator, unless he is very broad minded, is apt to minimize the importance of architectural necessities, and the still greater importance of the demands of modern medicine for the care of patients, giving too great prominence to administrative conveniences and economies, which fall within his own peculiar sphere.

Volumes have been written on hospital architecture; and one who may casually explore the literature will be impressed with the aptness to this subject of Saxe's satire on the six blind men who went to see the elephant; one touched his tail and was sure the elephant was "very like a rope"; another passed his hand along the huge side and found the elephant "very like a wall"; another touched an ear and saw that the elephant was "surely like a fan"; and so all six men described the elephant not one of them had seen. And so it is with the hospital architecture; each one favors that particular type that appeals to his own narrow sphere.

There is no other class of architecture that must conform to so many requirements of so many technically trained persons, all of them so specially trained that their outlook is more or less limited. A factory is designed by an architect to meet the requirements of some particular commercial enterprise, and the architect's views do not concern the man who is to pay for the building and who knows just the arrangement he wants, and an architect who would attempt to inject his own opinions concerning the interior arrangement of such a building, would be set right as to his place in the enterprise.

And yet architects are constantly injecting their opinions concerning hospital architecture, when they can have at best only the monkey-like intuition of mimicry to guide them—they saw someone else do it. This, however, is not always the fault of the architect; too often trustees, medical staff members, and hospital superintendents become deadlocked over their problems, and some one must act, and so the architect is compelled to do the best he can. There is hardly an architect anywhere who would not prefer to have some competent physician or superintendent or consultant relieve him of responsibility for settling the various medical and administrative problems.

Limitations of space would preclude a recapitulation of the evolution of hospital architecture, even if that were profitable; the story is a much hackneyed one; the periods marked in that evolution were born of extraneous conditions, beginning, one might almost say, with the Crimean war, when Florence Nightingale cut loose from all old moorings and established new bases founded upon conditions made necessary at that time. The American civil war marked a later period, and whatever changes came then were predicated on advances in medical science; still another period was marked by the Franco-German war of 1871.

So, without stopping to argue the matter, we see that changes in hospital architecture came about coincident with, if not entirely to meet the requirements of war. And yet the hospital, as we have it today, is not an accessory of war, but one of the prime factors in the reign of peace.

One of the reasons why it is and has been so difficult to settle the problems of hospital building, is that we are prone to look to the past rather than to the future for our inspiration. The reasons for things done in this particular field in the past are no longer cogent; we know quite as well as the Past knew, that fresh air and sunshine are necessary in the care of the sick; we know too that cleanliness spells a low mortality, and we must be mindful of this.

But there are many things that did not concern the past, with which we now must reckon. What wild dreamer of a generation ago would have conceived it possible that a hospital could be intended to house any but the most unfortunate and helpless of humanity who had no homes of their own in which they could be cared for during illness! And yet we have now come upon a time when the physician's first thought is to get his patient into a hospital, no matter how rich he may be or how fortunately situated in his home; and the patient who thirty years ago would have felt that the edict that sent him to a hospital was at the same time his death warrant, now feels that his greatest hope of an early recovery and competent care lies in getting into a good hospital. In that other day the treatment of the sick was entirely a bedside affair; the doctor made his diagnosis by physical examination of the patient and gave his treatment out of a bottle. Now how all this has changed! The doctor relies in only a minor degree upon his bedside findings, and upon the various hospital laboratories to a far greater extent. Drugs have become inconsequential in the treatment of disease; elaborate machinery that can be assembled only in a hospital has taken their place.

In that other day a hospital was a place within four walls. It was a thing apart from the community. Today, the hospital is not a building or a group of buildings; it is a state of the people, reaches into the innermost sanctuary of every home; its spirit hovers in guardianship over the everyday lives of the community at home and in the workshop. We teach our doctors and our nurses in the hospital, and through them the people, the principles of health conservation.

Wherever there is a human being there is a health problem, and wherever there is a health problem the modern hospital is there, and thus it comes to pass that the problems which are upon us and which grow more and more insistent, and are destined to a far greater importance in the future, are not the same simple problems upon which hospital architecture in the past was predicated.

It seems, therefore, that if we are to agree upon a style of hospital architecture for the future, we must look into the future for guidance, and not back upon the past. We still have the same problems of fresh air and cleanliness, but we also have others that are quite as urgent. For instance, in 1873, statistics compiled by the U. S. Bureau of Education showed that there were in the United States 149 hospitals, with a total of 35,453 beds. Of these, 51 hospitals with a total of 16,553 beds were used for the care of insane in publicly operated institutions; 43 hospitals with a total of 12,322 beds were public in character, operated by municipalities, for the care of the indigent sick; and there were only 51 hospitals, with a total of 5,453 beds for the care of patients who were not strictly public charges. To what has the evolution of time brought us? There are now in the United States more than 7,000 hospitals, including those for the care of the insane. There are 600,000 beds, more than 400,000 of which are employed every day of the year. There is invested in hospital property in the United States more than $1,500,000,000, not including the land. The maintenance cost of these institutions is more than $250,000,000 annually. In the year 1912 there were more than 65,000 phy-

sicians on hospital staffs, more than 100,000 trustees on hospital boards, and more than 9,000,000 sick people passed through the doors of these hospitals as patients.

And yet carefully compiled figures for a restricted area in the state of Massachusetts for 1912 show that only eleven per cent. of the sick who were under the care of a physician were treated in hospitals; and for the same time in Birmingham, England, perhaps the best hospitaled city in the United Kingdom, only thirteen per cent. of the sick who were under the care of a physician were treated in hospitals. So we can see that we have come upon a new day and upon entirely new problems.

Not only must the hospital be a place in which the sick can be properly taken care of; it must be a place that the public can afford to support. Hospital expenditures have run riot during these last few years under the impetus of a liberal hospital spirit abroad among the people. They have contributed eagerly to the building of great institutions, and toward their support. There are many of us who think we have reached our farthest limit in these expenditures and that it is the prime necessity of to-day to begin to curtail not only in the elaboration of hospital architecture, but in expenditures for maintenance. We are far more urgently in need of business methods in keeping with to-day's business era in hospital conduct than we are of the kind of architecture that we have, and only in so far as this architecture will lend itself to economies in administration and the scientific care of patients is hospital architecture a thing of prime importance. There is scarcely a hospital in this country that does not end its year with a deficit. There is not a single hospital in the land that has a sufficient number of nurses to care for the sick who are constantly clamoring at its doors, and yet we are building hospitals whose architecture is settled upon with an eye single to the few demands of a time that is no longer here. Fresh air and cleanliness are to be had in the tent upon the open, in a hut erected over night, and these are also in full measure in a structure that will answer the complicated problems of our own day.

A hospital for 500 patients, spread over 20 acres of ground, in single-storied pavilions, will require 250 nurses properly to take care of the patients, and a proportionate number of maids and orderlies who must be paid wages. A hospital, developed on modern, business lines, to take care of the same number of people can reduce the number of employes by thirty per cent. without any question, and consequently reduce the annual sum for its maintenance, in its most important feature, the pay roll, by that amount.

Then there are other considerations to be counted of importance. In Germany, the home of the one- and two-storied pavilion hospital, spread over a large area of ground, there is only one class of patients, and nearly all of them accustomed to only the simplest forms of living. Indeed it is a fundamental principle in German hospitals that patients must not be "spoiled" by undue attention, too elaborate feeding, and too great regard to personal comfort. The German hospital, indeed the European hospital, and the British hospital as well, is a prime factor in the continuance of the principle involved in the social status, viz., the rich and the poor—the rich to pay grudgingly and as small an amount as possible what is necessary to maintain life and working ability in the poor; and these have neither the ability to pay nor the spirit to complain; so that when we think in terms of the modern American hospital we are thinking of something entirely different from the form of that institution which we seem so eager to copy.

Architects, medical staff physicians, and trustees of hospitals in this country, as soon as it is determined to build a new hospital, rush away to Germany to learn how it is to be done; and when they return they build their institution by the blue prints they acquired on their travels, and from their notebooks. Of course, this fetish for German types is due to the fact that Germany has led the world in medical science since the advent of what we may designate as the pathological epoch in medicine, due to the achievements of Virchow, Behring, Koch, and a long list of scientific pathfinders. Based upon this era of scientific medicine came the recognition that bedside diagnosis no longer sufficed, and that it was necessary to have the patient under the better control of and within easy reach of the more elaborate apparatus in a hospital, if the best results were to be attained; and to meet these requirements came German hospital activities, which have continued to the present day.

But Germany was still Germany, a State in which every adult is a specialist, and before the influence of the specialist everything else is swept away. What did it matter that a patient should be wheeled across an open court for several hundred feet to the bath, or the operating amphitheatre, so he finally arrived there? Or why was it necessary to think about the patient's tastes or appetite if it became scientifically the proper thing to feed him on foods of certain chemical values to bring about certain metabolic changes? Because after all, Germany is a monarchic State where the individual counts for nothing at all and only the aggregate is worth while. Then too, Germany is a military State, and her hospitals must accord with the necessities of war.

These national attributes and ideals have moulded the modern hospital of Germany into a type, which has been styled the "pavilion" or "German" hospital.

But other reasons than national characteristics have contributed their share to settle the problem. Germany has no elevators as we know these modern conveniences. Germany has only one class of patients; the rich, who may not be used in the clinic, are cared for in their homes, as they are in England, although Britain is on the way to another day in this respect, by way of "nursing homes" for the rich. Every man, woman, and child in Germany goes to the hospital as a "paying patient"; if able to do so he pays for himself; if not, one of the three sick insurance organizations pays for him, but he obtains no special consideration on that account.

Let us now enumerate briefly some illustrations of hospital architecture, and of these there are two types, each having variations, viz., the pavilion hospital, and the block hospital. Perhaps the frankest expression of the first of these types is the Virchow Krankenhaus at Berlin, completed since 1906. This hospital is made up of a group of 57 buildings, each one or two stories in height, for a total of 2,000 patients, or an average of 35 patients to the building. Hospitals finished since that time, while some of them are not so uncompromisingly pavilion in character, all tend in that direction. The newer hospitals that have been built on the pavilion plan in this country are the Toronto General hospital of 11 buildings, two and three stories high, excepting one or two small groups that go as high as four and five stories, intended to accommodate 600 people; the new Cincinnati General hospital of 25 buildings covering an area of twenty-five acres and intended to house 700 patients, with an extra available space of 40 acres upon which it is contemplated at some time in the future, to erect twelve other buildings to double the capacity of the institution (Fig. 3222). The Barnes hospital of St. Louis is another of this same type, although even less frank in its pavilion character than any of the others. The new Cook County hospital, in Chicago, intended eventually to house 4,000 patients, is nine stories high in its administration building, with six stories as the uniform height for patients' pavilions—clearly a compromise; the new

buildings of Bellevue are also growing away from this type, with five, six, and even more stories to the pavilions.

It is significant that Johns Hopkins Hospital, of Baltimore, built originally on the pavilion plan, with one- and two-story buildings, has now entirely departed from that style of architecture in the newer buildings, notably the Phipps Psychiatric building (Fig. 3223), presented by Mr. Henry Phipps, which is five stories high, and the Brady Urological Clinic, of equal height.

Going far to the other extreme is the Peter Bent Brigham hospital, of Boston (Fig. 3224), built under the guidance and direction of Dr. H. B. Howard, one of the keenest hospital administrators this country has had. This is a hospital of one- and two-story structures, built at an expenditure of $1,250,000 for 125 patients, or a cost of $10,000 per bed. It should be said, however, that this institution is not a hospital in the sense in which that term is commonly used, but an institution for the extraordinarily scientific care of small groups of special cases, intended to be used largely for clinic purposes in connection with Harvard Medical School, and there should be no disposition to measure this hospital in its architecture by general hospital lines.

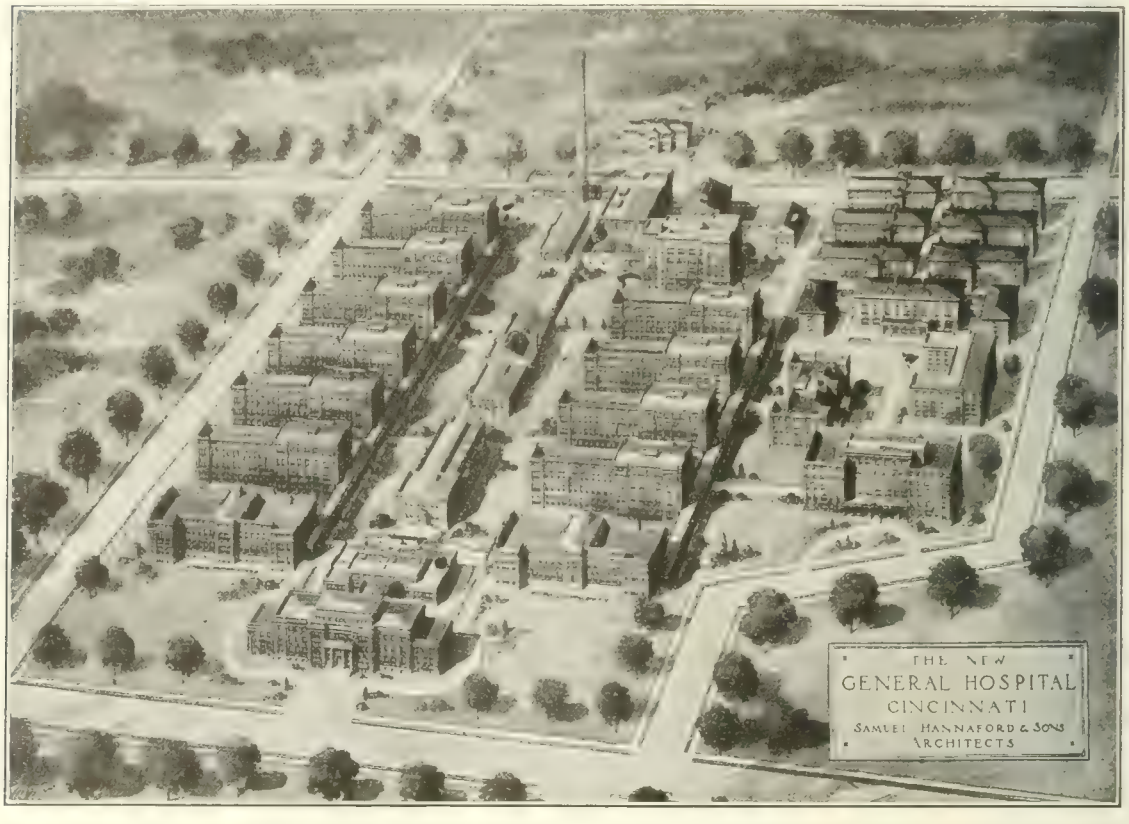


Fig. 3222.—The Cincinnati General Hospital.

The block plan of hospital has not had many advocates, and has not been in high favor up to the present time. One reason for this perhaps is the fact that for many years the hospitals for the insane in this country were built upon the block plan, which eventually gave way to the cottage type, to meet changing conditions in the care of the insane, that called for separation of patients into small groups, where they could be supplied with occupation best fitted for their cure; so that the block hospital came into disrepute as unfitted to the care of this class of patients, and this unpopularity followed for general hospitals also.

Only recently, however, there has been a tendency, however slight, to begin thinking about the block hospital as the possible institution of the future, the modern demands of medicine and the urgent necessity to curtail administrative expenses being considered, Mount Sinai Hospital, of New York, is perhaps the most conspicuous example of this type Grace, and Harper of Detroit (Fig. 3225), and several new additions to already established hospitals in Chicago.

It costs more to build a block hospital than it does to build one of the pavilion type. The increase in expenditure is due to several causes; first the walls must be very much thicker and stronger, the foundations must be heavier and must go down deeper, to bear the added weight, the materials of construction must be of a more exacting character, fire-proof, of high tensile strength, with generally steel construction and reenforced concrete. But against these added expenditures are the additional cost of land incidental to the spread-out pavilion hospital style; the greater area of excavating to be done; the immensely greater expenditure incident to plumbing, steam-fitting, and that great aggregation of specialties which we designate as permanent installation. In the pavilion hospital, these pipes must be run for long distances, and piping costs money both in material and in installation. These long reaches of piping are a constant source of expenditure for fuel, due to losses in transportation as, for instance, in live steam, hot water, and electric current.

In the block building, we have the pipe shaft located conveniently for the several floors, providing outlets at service rooms and elsewhere as they are needed.

The losses incident to the transportation of steam and electric current and hot water, are reduced to their lowest form in these vertical shafts; the piping itself is immeasurably decreased in quantity and the natural result is a considerable saving in the fuel supplies year by year.

Fig. 3223.—The Henry Phipps Psychiatric Clinic, Baltimore.

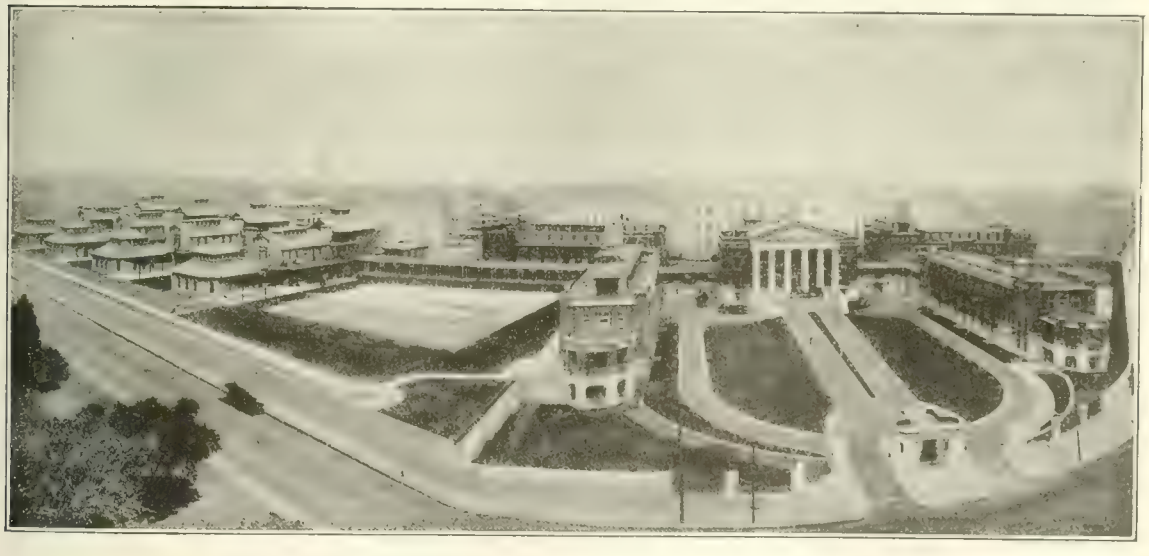


Fig. 3224.—The Peter Bent Brigham Hospital, Boston. An exaggerated pavilion type.

But these are not the chief values in the block hospital over that built in pavilion form. An English architect, Mr. A. Saxon Snell, counts the cost of building elevators as a strong argument against high hospitals, and thinks that employes, including nurses, would prefer to walk on the horizontal from pavilion to pavilion rather than to climb stairs. But in the block hospital no one is proposing that people shall walk up and down stairs. One prime purpose in building the hospital vertical in form, unit upon unit, rather than over a large horizontal area, is to make it unnecessary for employes, including nurses, to walk at all to get from place to place, but to make it possible for them to step into an elevator, ride fifteen feet and step out to perform a duty that would have occasioned a walk of perhaps two or three hundred feet, or possibly two or three times that, if the hospital were built on the pavilion plan.

The process of cleaning can be better attended to if employes are not obliged to wander about over

large areas of territory. It is a besetting sin of lower class employes that they waste their time wherever possible, and no greater opportunity exists than where they are obliged or permitted to wander over large areas to get to the points of their employment. It could be easily calculated that one-third of the time of an ordinary maid or orderly is spent in going about to get from place to place in a pavilion hospital where the elevator, its speed and the saving of energy would make these long walks and waste of time impossible.

As we have suggested in the beginning, it has become the universal custom in this country to copy after the German type of pavilion hospital. Now let us see just for a moment what Germany herself is doing at the present moment, about her hospitals.

hospital architects, in a recent paper in the *Zeitschrift für Krankenanstalten* of Leipsic, April, 1914, urges hospitals to cut down their expenses, to build more carefully, in order that maintenance may be more economical; while Magistratsbaurat H. Winterstein, of Charlottenburg, in the March, 1914, number of the *Heilanstalt* of Leipsic, speaking of the necessity to reduce costs of large hospitals, and speaking more particularly of the style of architecture of the Virchow Krankenhaus, says: "There is now a reaction against such extreme decentralization; we can even reduce expenses by merely building two houses together and still greater is the reduction if, instead of one- and two-story structures, we erect buildings of several stories; the basements, too, can be put to a better use than is

Fig. 3225.—The J. L. Hudson Building of the Harper Hospital, Detroit.

The first of the year 1914 the ministry of the Interior of Prussia, addressed a circular letter to provincial governors, making a request that districts and communities not having large funds at their disposal abstain from erecting expensive hospitals. At the same time, stress is laid in the circular upon the necessity that curtailment be made in the direction of ornamentation and unnecessary things, and not in features of hygiene and sanitation and administrative conveniences. Dr. Renvers, who more than anyone else is responsible for the famous Moabit Hospital of Berlin, recently stated that the Moabit Hospital was a mistake, and that the system of isolated, one-story wards, while good for an infectious disease hospital, was most unsuitable for general purposes, being wasteful of room, difficult of administration, and calculated to expose patients to risks of pneumonia in bad weather.

Stadtbaurat D. Spiller, one of the best of German

done at present; instead of erecting separate buildings for kitchens, laundries, bath houses, etc., the basements could be used for such purposes. Professor H. C. Nussbaum, writing in the *Heilanstalt*, April, 1914, says: "The pavilion system does not represent the ideal of modern hospital construction; communication between the various pavilions is unsatisfactory; people passing from one building to the other are exposed to the inclemency of the weather; the pavilion system lacks a large, quiet, and shady park, and the small gardens between the pavilions cannot possibly supply this want. There is too much noise and dust which have an unfavorable influence on the patient;" and he goes on to say that, "any form of building may be chosen, either pavilion form or houses of several stories."

Recent legislation in several States in this country has made it either mandatory or optional with towns and counties to build and operate general hospitals

out of the ordinary taxes. The only mandatory one of these laws is that passed by the last legislature of Texas, under the terms of which every county with more than 20,000 people is compelled to build and conduct a general hospital, and the law names specifically the following classes of patients that must be cared for; medical, surgical, obstetrical, children, and contagious diseases, with adequate provision for psychopathic service. Other States are falling into line, Iowa having been the first of all; indeed this scheme of hospital service is a new "Iowa idea." The Dakotas, Wisconsin, Missouri, Kentucky, and other States have enacted similar legislation, the only difference being that in all these States excepting Texas the people *may* rather than *must*.

This new development of hospital activity brings to the forefront the small general hospital for the care of approximately fifty patients, although these small hospitals are already in existence to the number of nearly 5,000 and occupy no small position of influence in nearly every community. But the small hospital differs in no respect from the large hospital except in the number of patients to be cared for, upon which in turn will depend a good deal the architecture. A fifty-bed hospital need never be higher than two or three stories although many architects will prefer to build foundations and walls sufficiently strong to carry an extra story, to make provision for future growth of the community; but in this enlightened day when the people in rural communities are quite as highly educated and quite as insistent in their demands for the best care and the best medical skill when they are sick, as those in large cities, the accessories for hospital service as quite the same as those in large communities. There must be good pathology and a place for doing it; there must be an *x*-ray equipment conveniently located; the surgical operating rooms must be adequate in every particular and equipped to do the same kind of surgery as in the large institutions, and the problem of the small hospital is simple only in the matter of size. The demands for administrative economies are even greater than in the large institution and the architecture best fitted to accommodate these economies must be kept at a low cost. And the small hospital differs from the large institution in that most large communities find it easy to raise money to build their expensive hospitals, and only in the difficulties attendant upon securing adequate support from year to year have the large and small hospitals a common and urgent problem to solve.

Having now approached our problem and discussed the various types of hospitals as an architectural problem, let us turn to some of the essentials that are fairly well standardized and take these up in the order in which they would naturally occur.

The Situation of the Hospital.—The advent of the automobile ambulance has greatly modified the necessity for hospitals to be located in centers of population. The modern automobile, capable of threading the crowded street at the rate of twenty miles an hour, artificially warmed, well ventilated, and provided with comfortable cots upon easy riding springs, has diminished the necessity to have the hospital immediately at the point where the patient is to be found; except in the few emergencies, it makes little difference whether a patient is conveyed one mile or five, hence there is a tendency to use a freer hand in the selection of a proper location for the institution, one where there will be an absence of neighboring high buildings, smoky factory plants, the noise of railway cars, public amusement parks and schools. In these conditions it is usually possible to find a location for a hospital at once pleasant in its surroundings and convenient to the population it is intended to serve.

The land question is important in deciding the location of the hospital; the emergency cases that must be got to the institution quickly are rare, but the "up patients" and their out-of-door necessities in the way of treatment are always an insistent problem; hence park space should be thought about. Then again we are realizing more and more as time goes on that pure food is one of the prime necessities in the treatment of the sick, fresh eggs, pure, fresh, unpasteurized milk, fresh vegetables, and fruits; hence many hospitals are thinking about their own farms. Many sanatoriums, and a few municipal institutions have already started in this direction; Cleveland has its Cooley farm of 2,000 acres; Philadelphia has its Bybury farm of 1,000 acres; Chicago has its Oak Forest of 250 acres, that will grow presently to the dimensions of another decimal; Milwaukee has an 1,100 acre farm.

This farm question has another meaning beyond the furnishing of food supplies for the acute disease hospital; it means a new era in the complete care of all the dependents of the community—a place of recuperation, with light, pleasant employment for convalescents; a place in which new occupations may be taught to those who have been handicapped by injury or illness, in which workshops and the crafts can play a part; a place of rehabilitation for petty offenders, who can be made useful while they are being taught the happiness of respectable employment.

Before a hospital is planned every condition of its future use should be considered, the size and character of the community it is to serve, and the kind of service it is to perform. The need of the hospital should be developed in a methodical manner, first of all. Are there not enough hospital beds already properly arranged to take care of the sick, without the new one? As an abstract proposition one bed to 150 of the tributary population might be taken, but in rural or well-to-do communities, where many sick can properly be cared for at home, the proportion might easily go to one for 300. Then, are all the classes of diseases provided for, and if not, which have been neglected? The available medical staff has much to do with the decision on this point; if there is a preeminent and aggressive obstetrician available, in all likelihood he will build up a spirit in the community that will attract women out of their homes to the hospital for their confinement. If there is a good eye man available, he will develop a good clinic and the people's eyes will be better cared for; and so on down the whole list. The predominant characteristics of the neighborhood must be studied; if it is a manufacturing community, the character of occupational diseases and injuries should be taken into account.

In all the planning, the one thing that must be kept ever in the forefront, is the ability of the community to build and afterward to support the hospital. A poorly built and poorly supported hospital is worse than none; and it may be comparatively easy to obtain money for the construction of a most pretentious building and a far different matter to obtain the necessary subscriptions to make up annual deficits, year in and year out; so the character of the promised support must be carefully weighed. There is no doubt that a hospital in a fairly prosperous community, supported by good medical men who will send their pay cases to it, and that makes no pretense to giving charity service, can be made self-supporting; that is only a question of good management, guided by careful bookkeeping. All charity work in any hospital should be financed out of special funds appropriated for that sole purpose.

The Site.—There is hardly an argument about the site for a hospital. It should be on high ground and at the greatest possible distance from other buildings, with as much land about it as can be had. It must be capable of good drainage and accessible to those public conveniences, street cars or trains, by which the people may reach it. It ought to be in the mind

of the hospital board to obtain possession, if within their means, of whatever adjacent property may be necessary to prevent the erection of interfering buildings at any time in the future; indeed, the original purchase of the land should by all means include whatever a long look into the future may develop as a need, both for actual building purposes and as a protection against undesirable neighbors. Formerly it was assumed that a hospital would have a depressing effect on land values adjacent, but this is no longer the case, and a hospital is now regarded as a desirable neighbor and its coming almost invariably serves to advance prices.

Divisions of the Hospital.—Having settled upon the size and general character of the hospital and its location and arranged for its building fund and its permanent support, and having purchased the land, the next thing is to settle upon the division of the bed capacity into medical services. Only very general outlines can be discussed in this connection. Each hospital will present its own peculiar problems, depending on conditions that may exist nowhere else; and conditions that exist today may change radically even before the building is ready for occupancy. So that in addition to planning divisions that would meet present needs, it will be desirable, indeed imperative, to build in so flexible a manner that an eye ward of today may be fitted next year for a surgical ward, or a maternity service.

Let us now try to fix some standards of a present division of the services, and for this purpose let us arbitrarily take a 50-bed hospital that must serve a community of 10,000 people, or one bed to 200 of the population, where average American conditions prevail. We will have a medical, a surgical, an obstetric and a children's service, as primary divisions. The medical service must include also neurological and skin diseases, and provisions must be made for male and female patients. In surgery provision must be made for the sexes, but other conditions are less arbitrarily insistent; gynecological cases can be placed in this surgical women's ward, likewise most eye, ear, nose, throat and orthopedic cases, except when these last belong to the children's department. Clean obstetric cases do not need much subdivision excepting that newly delivered women will need a quiet room until they are rested. The children's service is the most difficult to arrange, even if we ignore for present purposes the communicable infections; there are large and small children, males and females, which must be separated by sex at the fourth or fifth year at latest; there are very sick, nervous children and those with chorea, which must be isolated, and there are convalescents of both sexes who are noisy, mischievous and meddling; there are medical and surgical cases and last of all there are chronic cases so low in vitality that their resistance is all but gone, and that pick up new infections apparently from nowhere.

Fortunately we do not have all these complications of service in the hospital at one time and in a fairly flexible interior we can make the proper shifts to take care of those that come from time to time. But there are some divisions that must be recognized.

For the medical services it would seem that twenty beds, ten on each side, would suffice, a ward of say six beds, one of two beds, and two small quiet rooms of one bed each. The same leeway and the same number of beds should take care of the surgery. Six beds for children, in one large and two small rooms ought to meet average conditions. Four maternity beds should require four rooms, one for lying-in purposes, a ward of three beds for convalescents, a single room for recovery following labor—unless the labor room can be made to serve this purpose, and a small nursery. In this arrangement, we have made no provision for tuberculosis nor for the acute infections. If it should seem desirable to provide for these in addition, one three bed ward, and a small single room for a cougher should be sufficient for tuberculosis; and two small single rooms, with adequate equipment for their care should take care of the acute communicable infections that develop in the hospital.

Not counting these last two provisions, we now have a hospital of twenty-three rooms, which by fair average should be $12 \times 12 \times 12$ feet each, or a total patient capacity of 39,744 cubic feet. We must add another 60,000 cubic feet for administrative space to take care of laundry, kitchen, operating rooms, x-ray, hydrotherapeutic rooms, offices, store rooms, and the various service rooms for the ward units, making an area of approximately 100,000 cubic feet in the hospital.

There are a number of considerations that enter into the interior arrangement of these various service units; adaptability for purposes of light, sunshine, and ventilation are some of the factors. An eye ward need not be a well lighted ward for instance, and the maternity, nursery and labor room, needing the best kind of ventilation, need not have sunshine; somebody, ages ago, determined that operating rooms should have north light only, and that every consideration in the structure of the hospital should give way before this prime necessity; as a matter of fact there is no very good reason why operating rooms should face the north. We are getting over the "all white" fetish about operating rooms; awnings can be adjusted so that they will keep out the sunlight and there are enough dark days in the year when north light is not sufficient for operating purposes to justify the possible inconveniences incident to the use of awnings when the sun happens to be shining from an objectionable point.

Administrative space such as offices and reception rooms should not be permitted to occupy bright sunshiny space to the disadvantage of patients' rooms and wards. The x-ray room and the hydrotherapeutic suite need not have sunshine.

There are more important factors than any of the above that should be weighed in the arrangement of the ward units. The wards and quiet rooms should get some sunshine, the more the better, and it is highly essential that they should have sunshine, but it is equally essential that the arrangement should accommodate itself for other purposes as well. A little thing like the location of the drinking fountain from which the nurses must draw water in glasses for patients, may mean the difference of one nurse to take care of the ward. The nurse ought not to have to go far for anything that she may need, and above all else she should not be required to leave the ward for any considerable length of time, as for instance, to go to a serving room a hundred feet off, through two doors; there is no telling what may happen while she is away. The linen closets should be conveniently arranged and slop sinks should be so located that the nurses will not have to carry used bed pans out into public corridors. The toilets intended for the use of patients should be located nearby, where ambulatory cases may get to them without walking too far. The service rooms should be equipped with a good but small refrigerator so that nurses will not have to go to some remote part of the house for milk or cream, or the accessories to ward service. The nurse's own accommodations should be conveniently arranged so that she will not have to leave her patients and be out of their sight while she is writing a record or warming a soup, or doing any of the thousand and one petty jobs that a nurse must do at her own desk or away from patients.

We have been thinking in the matter of these interior hospital arrangements about a small hospital, the fifty bed institution that we began with. In larger hospitals the location of every part of the institution will be a special study and the above are only general

considerations for guidance, but when we begin to think about the ward unit, we are thinking about something precisely the same whether it is a large or a small hospital, the only difference being that the service accessories may be different. It may not be possible to have the linens in a small hospital in or adjoining the ward, and a common closet may be at a distance, available for two or three wards. The food

In Germany there are fewer accessory spaces connected with the wards (Fig. 3227), because the German patient gets less individual attention, which is more than made up to him in the better pathology and other scientific work expended upon him; but this work is done in a central laboratory and takes little or no space in connection with the ward unit.

In this country, we have our ward of from twelve to

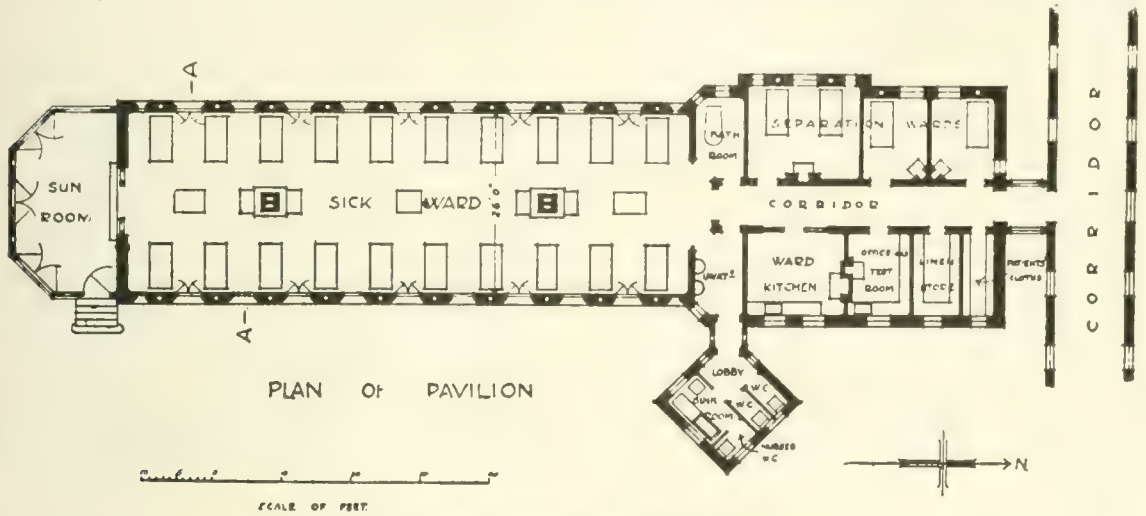


Fig. 3226.—English Type of Ward Unit.

service may differ, because of the smaller number of people to a ward, but the interior arrangement itself is a problem common to all hospitals large and small, general and special, and these largely bear upon the question of administrative economies and finances. Nearly every hospital administrator and architect, indeed nearly everyone who has come in contact with twenty patients, two to three small rooms adjoining for disturbed or recently operated, or dying patients, a room for food service, connected by dumb waiter with the main kitchen, a combination bath and toilet room, or better still the two separated; a slop sink or utility room in which there are sinks with large trapped openings into the sewer, utensil sterilizer, and perhaps venti-

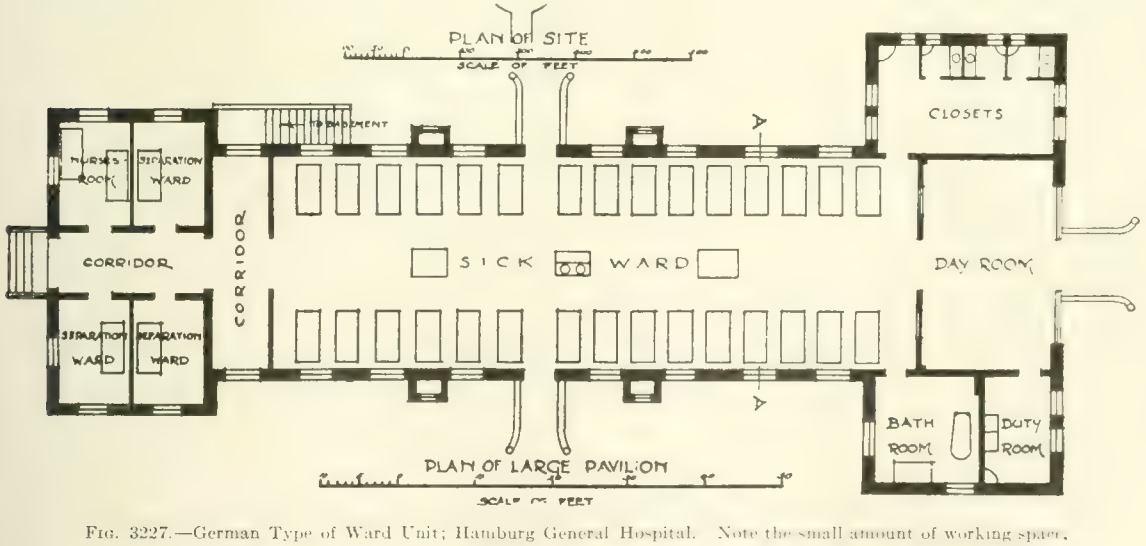


Fig. 3227.—German Type of Ward Unit; Hamburg General Hospital. Note the small amount of working space.

hospital problems in any form has made a suggestive unit. Two or three forms are illustrated.

The English type (Fig. 3226) differs not very radically from those employed in this country excepting that the old sanitary tower is retained. It is a hideous thing, obstructs the light from the windows on each side of it at certain hours of the day, and there are no compensations that offset this defect.

lated shelving for bed pans, urinals and the necessary nursing paraphernalia, and a nurses' record room. Off the surgical wards a dressing room is added and in some of the newer teaching hospitals a clinic room for one patient and half a dozen students, in compliance with the newer idea of bedside teaching in very small groups. Some hospital experts, Goldwater, for instance, like to separate each unit, if possible, from

the main hospital, by a cross corridor at the junction of the unit with the hospital, capable of a continuous fresh air current from side to side (Fig. 3228).

It will hardly be profitable to go into the special

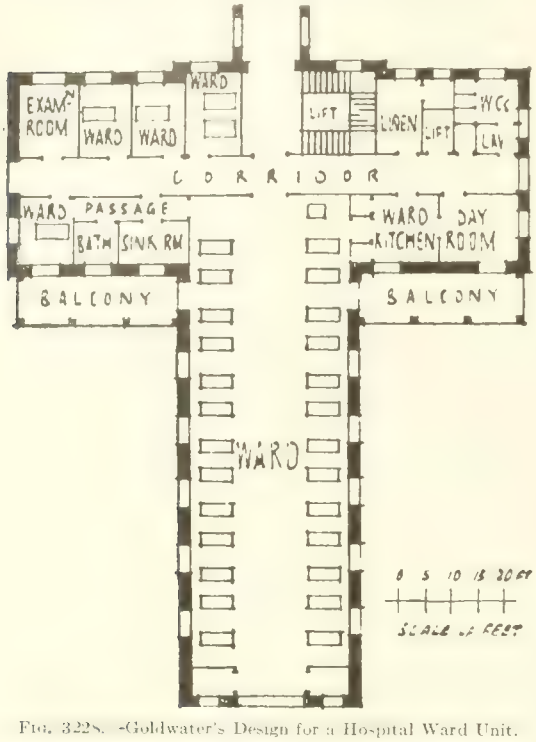


Fig. 3228.—Goldwater's Design for a Hospital Ward Unit.

architectural features for hospitals intended for special purposes. The care of the sick is pretty much the same whether it be a mental or nervous case, a tuberculosis patient, a maternity woman, a post-operative surgical patient, or a sick baby, and only a few features of these several institutions need be mentioned.

In a hospital for children, the windows must be low so that convalescents can see what is going on out of doors. The rooms and wards should be brighter than for adults, especially in the warmth of wall and ceiling colors; there must be a nursery, with special furniture; the baths should be so located and arranged that a nurse who is bathing a small child can see the other patients in the ward. This is best accomplished by the use of glass partitions between the bath and the ward, but there should be definite separation and the bath should not be in the ward because there will often be hot water and consequently vapor about the bath, and the question of humidity comes in and should not be supplied in that manner. The bath room for children should, therefore, be next to the ward and it should include a coil warmed linen cabinet, and a refrigerator large enough to hold the children's feedings.

There are two things about a tuberculosis hospital that we must always bear in mind: the first is that patients should be within easy access of the open air, either by porches or the open ground; second, expenses of construction must be reduced if the propaganda for the fight on tuberculosis is to be successfully continued; third, patients should be provided with open air sleeping porches, but they should have access to warm rooms for dressing and undressing; this arrangement may be provided in the way of French windows opening on the porches, for wheeling the bed out and in or as in Fig. 3230 where the bed is set into an alcove with outer and inner windows.

There is no good reason why tuberculosis hospitals should cost more than $500 or $600 per bed in a small institution, and $1,000 in the large, prominent, more elaborate hospital.

Hospitals for the insane and for epileptics and defectives are tending toward the single storied cottage plan, and these hospitals are very simple, but do not radically differ from other hospitals excepting that a far larger percentage of the patients are intended to be ambulatory and will not need the elaboration of service accessories that are required for hospitals intended for bed patients.

The maternity hospital need not differ in any respect from other hospitals. The lying-in rooms must be provided with extra plumbing, also the nursery, for the bathing of babies. The quiet rooms to which women are taken directly from the lying-in rooms, need not provide sunshine unless they are intended to be for the permanent occupation of patients. There should always be one or more rooms for suspected cases, according to the size of the service. Every new-born baby that gets sick should be isolated from the other maternity babies because so many of

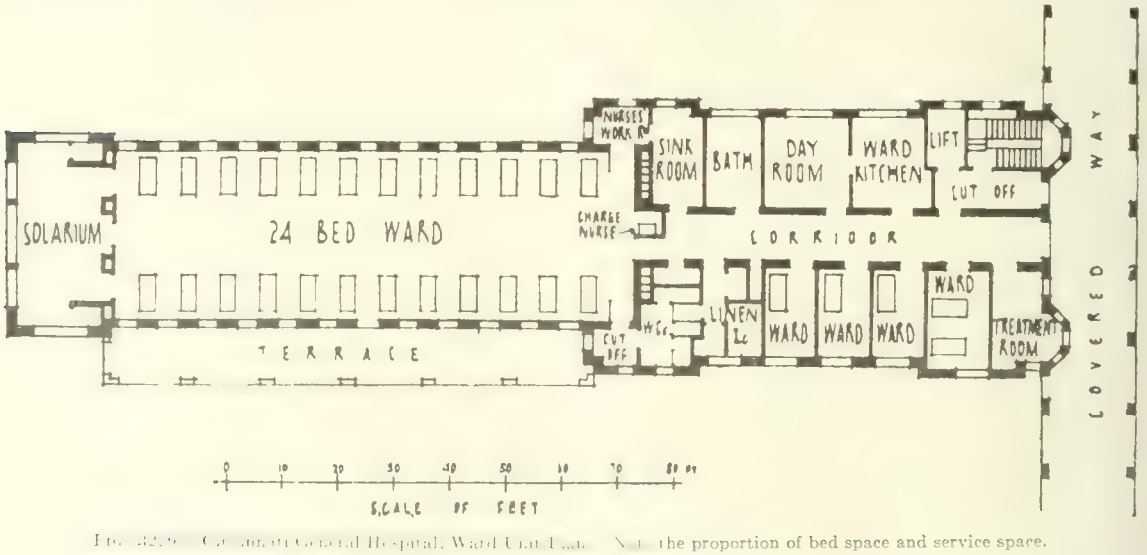


Fig. 3229.—Cincinnati General Hospital, Ward Unit Plan. Note the proportion of bed space and service space.

their troubles are communicable, and because the resistance in the new-born is very low. Such isolation rooms can be used also for the temporary separation of women who are suspected of developing some communicable infection such as erysipelas or puerperal fever.

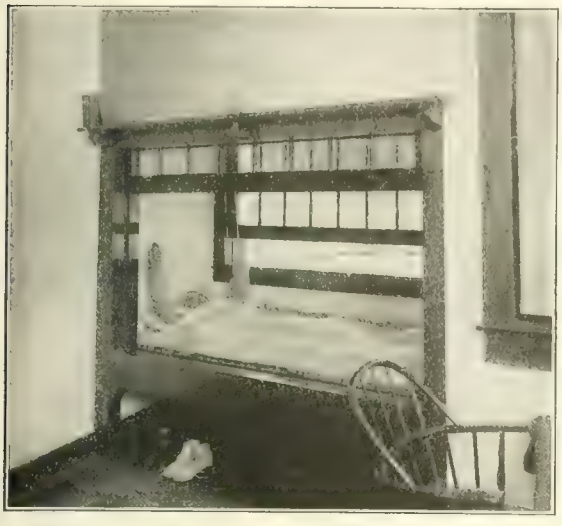


Fig. 3230.—Culver Patent Outdoor Sleeping Room.

Details of Construction.—*Fireproof Construction.*—There is no excuse in the present day to use anything but perfectly fireproof construction throughout the hospital building; it makes no difference whether the hospital is a small, private, or county hospital in the rural districts, or whether it is a great metropolitan institution of the block type. The cost for this kind of construction will be greater, but the upkeep will be less, and, even if this were not so, it is impossible that, when we understand perfectly well we can safeguard the lives of the helpless sick in bed in a hospital, we should knowingly proceed with materials of construction that will leave them unprotected. A hospital that cannot afford fireproof construction had better not be built at all, because the spirit that will permit a preventable fire hazard will be guilty of many inefficiencies that will make such a hospital worse than none at all. As a last resort, people can be cared for in their own homes, and in a locality where there is no good hospital even surgical operations can be performed there.

Then, what do we understand by fireproof construction? We mean brick, stone, marble, or concrete for the foundations and walls; which one of these materials we use depends on many things; first, the amount of money we care to spend in ornamentation; second, the locality in which the institution is to be built, because in some places stone would be cheaper and of a most desirable quality; at another place brick would be preferable, and at still another concrete would have first call. All of these materials have their advantages and their varying prices, although on the score of economy alone there is not very much to choose, since any of these materials can, by economical handling, be made to cost very little more than any other one of them.

For girders, where the building is too small to justify structural steel, concrete, re-enforced with spiral steel rods, is the choice material; wooden girders are obsolete in modern construction.

As a material for backing outside walls and for partitions, there is a choice of hollow clay tile and gypsum blocks. There is little to choose between these two materials; advocates of each of them claim certain advantages in the matter of their fire protective qualities. Where it is likely that walls are to be changed frequently, as in office buildings, gypsum blocks are preferable because they can be sawed and handled noiselessly; for this latter reason, also they are desirable for the building of partition walls in institutions that are occupied. On the other hand, gypsum blocks do not stand side weights, such as bracketed fixtures, as well as tile.

Floors.—There is no standard hospital floor; but it is pretty definitely agreed that the same flooring can not be advantageously used in all parts of the institution. There are those who like wooden floors for private rooms and wards in preference to the various lithics; there is no doubt that a finely finished cement or one of the compositions of lithic flooring or terrazzo is preferable for basement, serving rooms, and corridors; and no successful rival to the white vitrified tiles has appeared in the operating and dressing rooms.

Perhaps the floor favored at present beyond all others for hospital rooms, wards and corridors is battle-ship linoleum one-quarter inch thick, in solid colors; but the value of linoleum depends almost entirely on the laying of it. If it is laid badly, it is a nuisance and will not last, and is a constant source of irritation because it buckles and is uneven to walk on; moreover, the seams open up, slop waters get underneath and the material is soon rotted. There have been attempts to lay battle-ship linoleum by running it up the wall for three or four inches all around to a shoulder under a cove base; when used in this way, a cement colored to imitate the linoleum is used to finish the corners. This method of laying is not a success, and no amount of skill will prevent the corners from looking unfinished and unsightly. The proper way to lay linoleum is to run a turned cove base out onto the floor for six inches, bring the cement

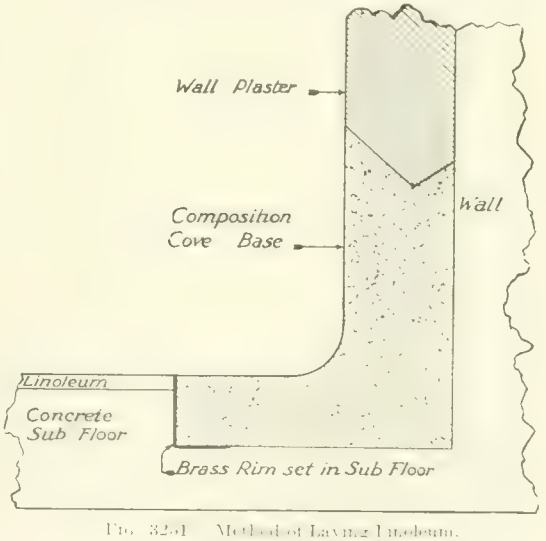


Fig. 3231.—Method of Laying Linoleum.

under-flooring up to within one-quarter inch of the top of the floor edge of the cove base and set a brass rim against the cove base so that the linoleum when it is laid can be supported by this brass rim, as well as the brittle breakable edge of the cove base (see Fig. 3231). When the linoleum is laid it should be cut to overlap all around and heavy sandbags or other weights should be placed on it and kept there for three or four weeks until the linoleum thoroughly settles to its place; then, it should be cut to fit snugly all over; a cement made for the purpose is put on the underside of every part of the linoleum with a whitewash brush; the linoleum is then set in place and the weights are again put on. After three or four days

the weights can be removed and a shellac cement can be used to seal all joints. The linoleum will keep clean if a light coating of melted paraffin is painted over it with a whitewash brush as soon as it is thoroughly dried, after it is placed; otherwise it is almost impossible to keep linoleum from getting stained and equally impossible to get these stains out. Paraffin serves to protect the fabric and there is almost nothing in the shape of a stain that cannot be washed out with hot water and soap if there is a first coating of paraffin until all the building operations are over. After the linoleum is down for several months it is best to paint it with two or three coats of shellac floor varnish, and the floor thereafter can be treated just as any wood floor and it will last indefinitely.

Door and Window Frames.—There is no excuse any longer for using wood door and window frames. These are made of drawn metal enameled and baked to represent any of the wood finishes desired. It should be insisted that door jams and window strips must be made adjustable and fastened with clamp set-screws so that the warping of a door or the drying out of a window will not cause a bad fit that cannot be overcome.

Doors.—Unfortunately, we have not been able to get a metal door that can be used in hospitals, on account of the noise they make coming in contact with metal frames; and the best we can do is to use heavy "built-up" veneered doors without panels; these doors are expensive, but necessary.

Windows.—Windows are a matter of taste; there are places where the French casement window is pretty, easily handled, and convenient; wherever these are used they should open outward and be controlled

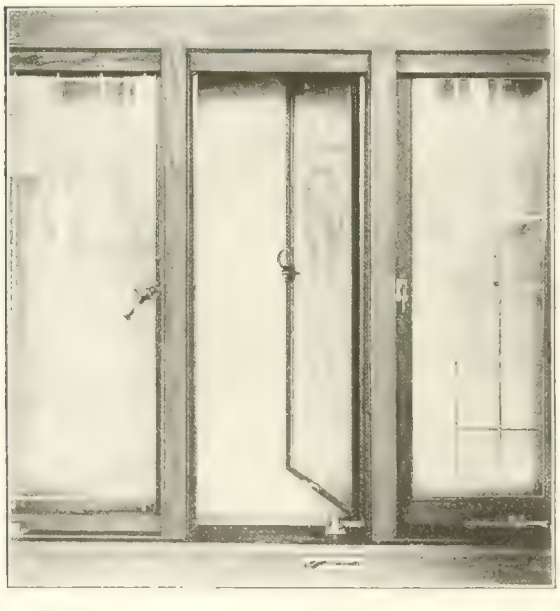


Fig. 3232.—Mechanical Control of Casement Windows opening Outward the Screen being on the Inside.

by some such mechanism as that shown in Fig. 3232, so that screens need not be raised in order that the windows may be moved. The old-fashioned two-part, counterweighted slide windows have not been improved on very much, as they are serviceable; sometimes there is a division into three parts in the slide window so that the upper part can be lowered and the lower part raised and air brought in both from above and below. Occasionally, this same effect is had by the use of a transom swung from above and opening outward, or, better still, a double transom with a compensating movement of the outer and inner halves, as in Fig. 3233.

Permanent Installation.—*Plumbing.*—Hospital plumbing is pretty definitely standardized. Designs of fixtures are a matter of choice and taste and individual conditions, but concerning the material out of which they are made there can be no compromise.

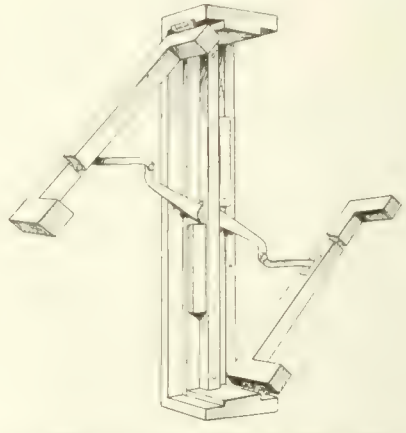


Fig. 3233.—Yale and Towne Transom Device.

Fixtures must be of porcelain, or at the very least if they are to be of enamel, the enamel out of which they are to be made must be of soft iron and the baking process must have been at least 2,600° F.; using this soft metal and the high temperature has the effect of fusing the silica and the metal. No waste pipes should be laid horizontally across floors or ceilings because in nearly every place in the hospital more or less marble dust is used in soap, and this dust forms an accretion in horizontal piping and the piping closes up with what practically amounts to a marble concrete. It is impossible to rout out this accretion and impracticable to break into the flooring to remove the piping. All sewer outlets should be trapped, and all vents should pay to the roof. Local vents may or may not be used, according to local conditions in each case and to conform to local laws; local vents are not always necessary. No pipes of any kind at any time anywhere should ever be exposed, because exposed piping must be fitted with loose collars through floors and walls which permit the passage of cockroaches, water bugs and other insects; then inside the walls the cold pipes sweat, creating a moist, warm atmosphere—an ideal breeding place, especially for cockroaches, which are now known to be the most harmful disease carriers that we have.

No matter how expensive or perfect a pipe is if used in a building it will never be satisfactory in appearance unless it is thickly nickeled. There is as much difference in nickeling of piping as there is in the quality of the material itself, and a great deal of piping is so thinly nickeled that a year of polishing will wear it down to the metal. The best piping is brass or bronze, and although considerably more expensive than iron it lasts so much better that the added expense will soon be wiped out by the low upkeep; moreover, brass or bronze piping does not corrode or rust, and there is nothing so offensive and objectionable as iron coloring matter in the water.

The Heating System.—There is very little to be said that is important in connection with the heating system. Radiation is a scientific matter and is an accumulation of accurate calculations at the hands of architects and engineers who understand this particular line of work, and it need only be suggested that

the best engineers seem recently to favor heating by hot water rather than steam, and it has been pretty conclusively shown that hot water heating is more economical than steam. The radiating surfaces in the case of hot water must be greater than in the case of steam; hence, the radiators themselves will cost a little more; but unless the added surface is allowed, the system will not warm the building sufficiently in extreme weather. The piping for the heating system should be quite as good as that for plumbing. Radiator valves must be of the thermostatic type; the architect will be the best judge as to the particular make.

Ventilation.—There is no doubt that mechanical ventilation is to play an important part in hospital and sanitorium installation and administration in the near future, but up to the present time no definite rules have been laid and no standards have been set upon which the ideal ventilation system can be realized; in fact, there is hardly an institution in this country to-day whose mechanical ventilation system is efficient and helpful. There are many side problems to be considered in connection with ventilation and the scientific work has yet to be done for the settlement of some of these problems. It is very certain that mechanical ventilation cannot be employed to any extent whatever in helping to control either temperature or humidity, two most vital factors in hospital air; whenever washed air is heated before it is distributed into the wards or rooms it immediately loses its freshness; warmed air introduced into a room or ward gives the air a feeling of deadness, and supplies air very much like that one feels when going into a room that has long been closed up. There is no doubt that the movement of air in a room has as much to do with the comfort and well-being of patients and the oxidation of the blood as either the temperature or humidity, or even the quality of the air itself.

New hospitals that can afford it should have air ducts installed as though it were the intention to put in mechanical ventilation; but until some standardized system is evolved, hospitals might just as well save their money. Architects will not agree to this, but architects leave the hospital as soon as it is ready for the occupancy of patients and they are not well informed about the results of administration under varying conditions. The few architects who do know the difficulties that hospital administrators have in their attempts to get efficient service out of mechanical ventilation plants will sympathize with these sentiments, and these men are to-day calling upon the medical profession and upon experts in hygiene and sanitation, and the various technical engineers, to give them a solution of this problem.

Refrigeration.—There is no longer an excuse for even small hospitals being without mechanical refrigeration by means of a system of pipes from a central refrigeration plant. Large hospitals will install either the ammonia or the carbonic-acid gas system, the pumps of which are motor driven from the central station. There are a number of recently designed systems for small hospitals that work automatically for the cooling of circulating brine, some of which are most ingenious and efficient; especially is this true of an automatic gas-heated, pump-driven machine recently placed on the market. A small installation of this type costs three or four hundred dollars and is sufficient to cool three or four moderate-sized refrigerators placed one above another on different floors. The principle of operating is based upon a thermostatic temperature control, which works by turning on the gas which drives the pump when the temperature in the refrigerator rises to a certain point, and by reversed action turns off the gas down to the pilot light when the temperature is reduced to the designated point. Of course, a certain amount of ice must also be made in the hospital and any of these mechanical refrigeration machines can be employed to make a specified quantity of ice every twenty-four hours.

There is very little difference between the ammonia-machines and those operated under the use of carbonic-acid gas and calcium chloride as a cooling medium. The main point is that the installation must be high class in every respect, so that there will not be leaks anywhere; and speaking of these leaks recalls a diversity of opinion as to whether ammonia or carbonic-acid gas is the better medium; there is a certain amount of fear connected with the use of ammonia due to the fact that explosions have occurred; these explosions are now discounted in the new installations and present practice will hardly allow them to occur. Ammonia is cheaper than carbonic acid and can be used over and over again, and the upkeep of an ammonia plant need not take into account the loss of ammonia by leakage. On the other hand, the leakage of carbonic-acid gas gives off no odor and cannot be detected except by the necessity to supply renewals of gas at intervals. There are many plants using carbonic-acid gas with calcium chloride freezing mixtures that have gone on leaking for years and the only means of detection is in the monthly bills for gas. The ice machine people, using both types of machines, have developed their science to a very exact and efficient state, and all of the systems have given an immense amount of satisfaction to administrators and trustees.

Hospital Construction Costs.—Under pressure of the increase in the number of hospitals, costs of construction are being constantly decreased by simplification in methods, by systems of manufacture of finished products, and by the larger quantities being used. There are no hard and fast rules by which hospital construction can be gauged as to cost. There are choices as to quality and price in material, for almost every part of the institution, and hospital architects and administrators can, within limits, fix beforehand the cost of an institution they propose to build by certain economies planned in various directions, as, for instance, the elimination of ornamentation both in the general architecture and in the finish of details.

There are a few figures which might be of interest concerning the costs: a plain, unornamented building, reasonably well equipped as a modern hospital and without furnishings, can be completed on a basis of about twenty-five cents per cubic foot of space, measurements to be made over all; or, figured on another basis, the same hospital will cost about $2,000 per bed, assuming that the administrative spaces—that is, all the areas not actually occupied by patients—are not excessive. By substituting cheap plumbing and cheap fixtures, by giving way here and there concerning the fireproof character of the structure, by the use of cheap hardware, cheap flooring, cheap doors and windows and frames, these costs can be materially reduced; but such reductions will always be at the expense of the upkeep costs in the future, and while it is nearly always comparatively easy to obtain money for the building for a hospital, it is always a difficult thing to obtain the necessary funds to cover deficits from year to year, so that an extra effort should always be made to put in the best materials and to use the best methods in construction, which will be repaid abundantly in the future by a low upkeep cost. The present high costs, and increases during the past few years, are not due to increased cost of materials, but to elaboration in construction due to an unwholesome rivalry in the matter of ornamentation, and the constant pressure of medical science for more attention to patients, which in turn means greater elaborateness in all the permanent installation.

JOHN A. HORNSBY.

Hospital Organization and Management.—HISTORICAL.—During the seventeenth and eighteenth

centuries in the American colonies the so-called hospitals were almshouses or pesthouses; hospitals proper did not exist. Hospitals for contagious diseases, better known as pesthouses, were erected in connection with all commercial cities, not so much from motives of humanity or a desire to care for the sick as to protect the public from the constant peril of immigrants suffering from infectious diseases who came into cities, usually by water. In both the seventeenth and eighteenth centuries ship-fever, owing to the long voyage from Europe and its inevitable hardships, frequently attacked immigrants and menaced the life and health of the residents of the port where the ship happened to land. The same was true of smallpox. Prior to the introduction of inoculation and afterward of vaccination, ships coming into port often brought a crew or passengers infected with this disease; hence it became necessary, in order to protect the health of cities, that special provision be made for sick strangers. To supplement this provision a system of almshouses or almshouse hospitals came into being, where the sick and dependent could be cared for and ministered to as their necessities required. No adequate provision, however, existed anywhere for the care of the sick, the indigent or the insane and whatever effort was made to meet this crying necessity was haphazard and fragmentary. The hardships and privations attending pioneer conditions in a new country and the disease and wounds which followed constant warfare with savage tribes fostered low standards of medical care and nursing. Physicians were imperfectly educated, and, as a rule, destitute of large experience and nurses were not trained at all. The sick and wounded thought themselves fortunate to be under the shelter of a roof and expected and received little attention from physicians and nurses. Under such conditions the care of the sick fell upon kindhearted friends and neighbors who did the best they could; it was "watching the sick," however, and custody rather than nursing. It was undoubtedly the only available care in an exceptional condition of society and in no sense nursing as we now understand it. Later, when the growing segregation of families in city life and the disappearance of the neighborly interest developed by pioneer conditions because living had become secure and people could dwell together without the interest or friendliness developed by a common danger, the evident need of something more was felt. People no longer recognized the duty of giving personal care to their sick neighbors and yet felt that they owed a certain responsibility for their care when friendless, sick and destitute. This gave origin to the general hospital for the care of the indigent sick of the community, which, however, was not thought of until 1751 when the first hospital deserving the name was founded at Philadelphia at the suggestion of Benjamin Franklin. The reason assigned was the duty of the public to give to the inhabitants of Philadelphia as good care as was given to the homeless and friendless immigrant, whose care had been earlier assumed, perhaps grudgingly, to avert worse evils because of the contagion which he carried. A petition written by Franklin was presented to the Pennsylvania Assembly in 1751 and after proper delay a bill establishing the Pennsylvania Hospital, was enacted and became a law the same year. Nearly $14,000 was raised by popular subscription to erect the building and the state appropriated about $10,000 in addition. The managers of the hospital, however, did not wait for the erection of special buildings but promptly rented a private house and opened it for the care of a few patients and continued to occupy it until the buildings of the hospital were completed and occupied in 1756. Like other hospitals erected at the same era provision was made at first for the insane as well as for the sick. This grew out of the fact that no accommodation for the care and treatment of persons deprived of their reason existed anywhere in the country. As it was inhumane to confine such insane persons in jails and lock-ups it was deemed essential to make provision for them in cells or similar places of confinement in connection with the hospital and under its care, generally in the basement. The dominant idea in establishing this hospital was the care of friendless, sick and insane persons.

A second hospital was the New York Hospital founded in 1770 under a charter granted by George the Third at the instance of Drs. Middleton, Jones, and Bard, then physicians of New York. The charter was granted in 1771 but owing to the breaking out of the Revolutionary War the hospital was not opened until 1791. In the erection of the New York Hospital the dominant idea seemed also to be to provide for the necessities of sailors and immigrants in order to prevent the introduction of infectious diseases into the growing city. Early, however, in the enterprise it became imperative to provide for the care of the insane and out of it has grown a large branch hospital in the country which has served a most important purpose for a century. Then followed in order similar hospitals, in Boston, the Massachusetts General Hospital in 1811 with a department for the insane, and in Baltimore, the Hospital of the University of Maryland, in 1823.

These institutions at first were semi-private corporations, in two instances assisted by the State but managed by private citizens and erected to meet a manifest public necessity. They were modeled to some extent upon the hospitals of England but differed materially in their object and scope. There being no recognized pauper class in the United States as in England, those who were the recipients of charity were persons temporarily in want of care or insane persons. From such humble and inexpensive beginnings a system of public hospitals of different classes has developed throughout the United States. In addition to the large corporate hospitals, above referred to, many similar hospitals have been established in all large centers of population for the treatment of acute diseases and for emergency surgery. In some instances they have private rooms for those who are able to pay the cost of rooms and board and fees to surgeons and physicians for professional services. They represent the highest grade of general hospitals in the country and because of their method of government being free from political control and the character of their organization, they command the respect and confidence of the public.

Their trustees are selected for probity, good judgment, and approved business ability and as they serve without pay they bring into the service of the institution a grade of ability which can rarely be obtained in institutions where political control is the rule. The hospitals also assist in medical teaching and by their clinics and ward classes accomplish much for the training of physicians and nurses.

There is also an extensive system of State hospitals for the care of diseases like insanity which are chronic in character and which, as they deprive the patient of his civil rights, require a degree of custodial care which ought only to be exercised by the sovereign power of the state, or like tuberculosis which from its chronicity and the necessity of isolating the patient in favorable climates and, above all, from the fact that the cure of the disease has grown too large a problem for private charity to deal with and must fall upon the state. State hospitals are generally under the control of governing boards appointed by the governor with the consent of the Senate or Council and composed of men of character and standing who are actuated by high motives in assuming duties which bring much hard work, considerable anxiety, and little or no pecuniary return.

There are besides in many States, municipal and county hospitals for the care of sick paupers of the

chronic class, hospitals for miners, iron-workers, railway employes, etc., often maintained by mine owners, and railway organizations.

Municipal hospitals generally care for the city poor and neglected, for chronic cases of diseases and for venereal disorders. The municipality also, as a rule, cares for the more severe contagious diseases like smallpox, diphtheria, and other acute infectious diseases. As the infections are too virulent to permit their victims to take long journeys such hospitals are under local control in order that patients may be isolated and treated at the earliest moment with a minimum of exposure to others.

In such a general summary no mention is made of special hospitals like eye and ear, children's, orthopedic, nurseries and women's, or private hospitals. These are generally departments of other hospitals or private enterprises, and, if the latter, they commonly are the creation of a physician who has become interested in a line of personal work from which he derives profit either directly or indirectly and do not require special mention here.

Such public hospitals whether State, county, municipal, corporation controlled, or corporate should be governed by unpaid boards. A payment to a manager or trustee however trifling impairs his usefulness and dignity, because no sum of money can adequately compensate the large-minded public-spirited man whose services are needed by public hospitals. If a small compensation is paid to trustees, and no matter how small the sum may be, some person will arise to seek the position for the money which is in it and thus exclude men of higher capacity and larger experience who might willingly serve without compensation, and esteem it an honor and a privilege to give this service. Such men bring to their duties a range of ability and business skill which cannot be adequately rewarded by any salary.

All boards of trustees of public hospitals of every grade should be absolutely free from political control and their tenure of office should not depend upon the changes of political parties or the vicissitudes of elections. No officer should be appointed because he belongs to a particular party, nor should he be removed from office for political reasons.

It is important for the good of the hospital that its management should not become a one-man affair. In many hospitals with a large board of managers it often happens that some one person exercises preponderent influence because of his dominating personality and keen interest in the work. The concurrent and harmonious services of men of varied talents and breadth of interests are required by every hospital and should not be lost to it through the inconsiderate action of any one person however exceptional his powers may be.

Hospital Organization.—A good working organization is of prime importance to a general hospital planned to do proper work in the branches of medicine and surgery. Although an imperfect organization may accomplish excellent results provided its administration is exceptionally good, such a condition may bring an unnecessary strain upon all concerned in the work of administering the hospital and interfere to a great extent with the ease with which the daily routine is accomplished. Hospital administration is full of difficulties and the labors of officers should not be increased needlessly, but rather they should be made lighter wherever it is possible to diminish them. The plan of organization ought to be thoroughly thought out before a hospital is opened, in order that it may be competent to meet all emergencies or requirements.

Many hospitals, unfortunately, have had a haphazard origin and for years, thereafter, have led a hand-to-mouth existence, being understaffed and without sufficient officers to do the necessary work with ease and efficiency. They often begin as small establishments with limited resources and apparently without special thought of future development; hence, as they may eventually fail to produce good results because of inefficient organization, it often becomes necessary to fit the plan of administration to the larger work of the hospital, and the effort to accomplish this is often difficult.

A cardinal point in successful hospital organization is the careful limitation of the powers and duties of each and every department. There should be no overlapping of duty or authority but the boundaries of each should be scrupulously marked out. The trustees or managers of the hospitals are the underlying body and repository of authority and power; from them should be derived the functions exercised by all executive and subordinate officers of the hospital. Being the governing board they establish rules and regulations for the management of the hospital and thus become responsible to the public for the conduct of its affairs. They have charge of the property and legally control every officer, patient and employe. This control cannot be exercised personally by the board of trustees but it must be effected through the officers which they appoint to act as their agents. The activities of such agents must be so coordinated that one agent will not interfere with another; they must be so controlled and directed as to supplement each other and thus discharge the duties required by the work of the hospital It therefore becomes essential that the trustees or managers should have a representative constantly in the hospital clothed with their authority as a means of communication between them and every department of the hospital. In this manner only, it becomes feasible for the trustees to bring themselves into relation with all parts of the establishment and to breathe into it the breath of life so that the whole may become a single vital organization. Such representative of the board of trustees is known in England as a secretary or warden, and in America as superintendent or director or chief executive officer.

Subordinate to this chief executive officer there should be independent departments of service under able, experienced, and competent heads, each supreme in his or her own department, but responsible through this officer to the governing board—in other words independent heads responsible for all results to the management of the hospital.

The Trustees.—The trustees as holders of the property are responsible for the management of the whole establishment. All boards of trustees, as I have already intimated, should be independent of political control, and should be selected solely with a view to their competency to manage properly the property and concerns of the hospital. The membership of the board should not be large. In many instances a mistake is made in selecting too large a number of persons for a governing board. In several hospitals the board of trustees or managers consists of twenty-four persons; in some English hospitals, boards of managers frequently number forty or fifty persons,* the result being an unwieldy body which cannot become interested as a whole in the details of hospital management, and consequently fails to develop a feeling of responsibility. In such large boards it is usually customary to appoint a smaller body known as an executive committee, to which is committed the actual management of the hospital, the trustees in general being mere figure-heads. A board of trustees should not consist of

*In "The Order of the Hospitals of K. Henry VIII and K. Edward VI [viz., St. Bartholomews, Christ's, Bridwell, and St. Thomas, by the Maior, Cominalite and Citizens of London, Governours of the Sayd Hospitalls, 1557," it is provided that "the number of persons that shal Governe shall be not [illegible] the leaste."

more than ten or twelve members and often a smaller number is equally efficient. They should be good business men, preferably not physicians or clergymen or gentlemen of too abundant leisure. A man who is engaged in business and is accustomed to business ways is usually more efficient in the discharge of duties than one who assumes the responsibility of a large hospital for lack of something else to do. As a rule trustees should be appointed for long periods of service preferably for life. In some boards a retiring age has been selected which has proven advantageous to the hospital by bringing into service younger men who are better able to endure the fatigue of the routine work of the trustees. There comes a time also in the history of every self-perpetuating life board when, through the course of nature, all the members become advanced in years, it is found that advancing years bring a certain timidity and hesitation in meeting new issues. It is to the old man much easier to keep on in the old way than to strike out new paths, or to meet new situations as they arise. In some boards women have been appointed with a degree of benefit to the internal management of the house. In State institutions for the insane also they often prove of great service by furnishing a guarantee to the people of the State that the rights of patients, and especially of female patients, are considered, conserved and protected.

Boards of trustees should have regular meetings at stated intervals which all members should attend for the transaction of general business. To assist the board in the discharge of its various duties, it is essential that such general business be prepared through regular committees, as, for instance, a visiting committee to visit the wards and buildings of the hospital, to inspect their condition and report upon them to the whole board; an executive committee to act in the place of the general board when it is not feasible to call it together, and to consider matters in committee to be reported subsequently to the board for final action; a finance committee to have charge of the property of the institution, to invest its funds and look after its financial and monetary interests; and a building committee to direct the details of construction of new buildings. A board organized with such committees is thus usually able to utilize the varied capacities of its members. Many men are not much interested in the internal management of the hospital, but their training as business men makes them extremely valuable as members of a finance committee. Others are interested in the hospital solely, and give valuable service in visiting the wards and in improving the condition of the institution. Hence it is important that there should be a wide range of talent in connection with every board. There is work for all.

Such boards should be unpaid; they should be selected from among people who have achieved a degree of success in life and who take pride and pleasure in contributing to the public good without expectation of reward. It cannot be repeated too often that to fix a salary for such men or to give them an honorarium for attendance upon meetings is unwise. No money can adequately reward an experienced business man who gives his time and experience to the public good, and every high-minded man prefers to give services, which cannot be paid for, rather than to accept a compensation which is manifestly inadequate and in no respect commensurate with the amount and quality of service rendered.

To this board should be referred all matters connected with the general management of the hospital, but it is not wise that the board should assume executive functions and enter upon the minute details of management. The principal function of such a board is to select a competent executive head for the hospital; when selected, to him should be committed the responsibility of looking after the manifold details of hospital administration. In many boards which have grown from small beginnings and without due thought on the part of founders of the future development of the institution, it has been customary for trustees to assume certain minor executive functions, but at the expense of the true efficiency of the institution.

The Superintendent.—The superintendent, director or chief executive officer should be carefully selected by the board of trustees. He should be a man of experience and of sufficient large-mindedness to enable him to appreciate the work of subordinate and coordinate officers. It matters little whether the superintendent is a man or woman, whether he is a physician or layman, provided he be the right person for the place. As a rule, in large general hospitals, especially those connected with medical schools or where there is a large staff of medical men, less friction exists for the superintendent, if he is a physician than if a layman. As a physician he clearly recognizes the relations of the medical staff to the hospital, appreciating on the one hand the importance of the requests and demands of medical men, and also equally aware that such requests and demands are not always of vital importance. A layman might regard all requests for supplies and service as of equal importance or if he thought otherwise he could not speak with authority.

There are many hospitals whose means are limited, and it is not practicable to have as many employes and administrative officers as are required in the larger hospitals. For a hospital thus circumstanced a woman well-trained in hospital work makes a desirable superintendent. As a rule a trained nurse who has become experienced in hospital work is preferable, but she should have in addition a familiarity with housekeeping, with the management of the laundry and the general charge of employes of different grades. Such a cruel amount of work ought not to be assumed by one who also has charge of an important training school for nurses.

It is important that the superintendent should be the representative of the board of trustees in the hospital, and in order to fit himself for this duty he should be required to be present at the meetings of the trustees, to inform them as to the business of the hospital, and thus prevent inconsiderate action based upon an imperfect knowledge of actual conditions. Although this is a digression and not germane to this part of the discussion the writer would deprecate all meetings of the board of trustees held elsewhere than at the hospital itself. It is also unwise for a board of trustees to have ex-officio members, because such members generally do not find it convenient to be present at regular meetings, and meetings of boards must sometimes be held at the offices of ex-officio members, like governors, comptrollers or attorneys-general, in order to secure a quorum. Such meetings do not permit the presence of the executive officer of the institution and the trustees, in his absence, may take inconsiderate action from a lack of accurate knowledge of the state of affairs at the institution.

The superintendent should be permitted to select his subordinate officers, but should not have absolute power of appointment. It is desirable that he should recommend to the board, but that the board should possess the ultimate power of accepting or rejecting his recommendation. In any event the subordinate officer so appointed should have behind him the authority of the board, and his salary should be fixed by it.

The Medical Board.—To advise a board of trustees in all matters connected with the medical administration of the hospital, a medical board should be organized, composed of the heads of the different services in the hospital, for example, the head surgeon,

the head physician, head gynecologist, obstetrician and pathologist. If the superintendent is a medical man he also should be a member of this board, and should be required to be present at its meetings. It should be the duty of such medical board to select and to recommend to the board of trustees all members of the medical or surgical staff, and such persons should be appointed by the trustees upon the recommendation of the medical board. Such recommendation ought not, however, carry with it the compulsory duty of appointment on the part of the trustees. There may be reasons why it may not seem wise to them to approve the recommendations of the medical board. No one should be appointed who is not recommended by the medical board; but when the original recommendation is not satisfatory to the trustees, the medical board should present another candidate with the expectation that he will be satisfactory.

Coordinate Departments.—Under this head are included the training school for nurses, the household and laundry, the kitchen, and all outside departments. The heads of these departments, as the superintendent of nurses, the matron, the purveyor and the supervisor of buildings and grounds, should all be selected by the superintendent of the hospital, and recommended to the board of trustees for appointment.

The superintendent of nurses should be the principal of the training school, and should have charge of all the nurses. She should select and recommend for appointment her nurses, orderlies and ward maids; she should have charge of the nurses' home, of the different wards of the hospital, and should be the keeper of the surgical supply room. The question frequently arises in hospital administration whether the superintendent of the hospital or the superintendent of the nurses should select the nurses and orderlies. It is preferable that the selection of nurses and orderlies should be committed to the superintendent of nurses, principally for the reason that she is held responsible for good nursing and for the work of nurses and orderlies. This would seem to carry with it the desirability of selecting agents satisfactory to the superintendent of nurses through whom the nursing and care of patients may be carried out. She ought not to be held responsible for the conduct and efficiency of persons in whose appointment she has no voice; hence in every institution pupil nurses should be selected by her and recommended to the board of trustees for appointment through the superintendent of the hospital. If, for any reason, the appointment of any person is not thought advisable the superintendent of nurses should have the privilege of making another recommendation.

The matron should have charge of the household, that is the care of the rooms devoted to the medical officers and employes; she should see that they are kept in a state of proper cleanliness, that the furniture and furnishings are supplied and maintained and that house maids and other employes are properly disciplined and required to keep proper hours. In connection with this she should have the care and responsibility of the laundry and its efficient management and proper work. In many institutions the matron, in addition to this, has charge of the kitchens and the cooking of food. In English institutions, in fact, the matron has charge of the training school for nurses also, in addition to the kitchen and laundry. In my judgment it is preferable to divide the duties in the manner mentioned and to relieve the matron of the charge and responsibility of the kitchen.

The purveyor should be responsible for the purchase of supplies, for their delivery and inspection, for the employment of cooks and the proper cooking and delivery of food to various parts of the hospital. Such an organization of the kitchen gives fewer opportunities for a divided authority. In many institutions, in the experience of the writer, where the purchasing agent and the matron divide the responsibility of the food and its cooking and serving, the purchasing agent generally asserts when criticised about the food, that he purchases good supplies but the matron spoils them in the cooking, while the matron asserts that she cannot provide proper meals with the improper supplies furnished by the purchasing agent. Under a purveyor with the duties above mentioned the purchase and cooking of food contemplate an identical responsibility. If food is not good and it is not the fault of the supplies, it must be the fault of the cook. Where it is part of the purveyor's duty to employ the cook and to supervise his work, it can be seen readily that the responsibility for imperfect meals comes upon the purveyor's department, and that he should remedy the defect without appealing to another department of service.

Supervisor or Business Assistant.—In many institutions it is customary to group together a variety of duties connected with the material side of the hospital work under the general supervision of the superintendent, such as the duties of the engineer, and of the carpenters and painters engaged in the repairs and renewals which are almost equally essential. It is preferable in the opinion of the writer to relieve the superintendent as far as possible from such mechanical details in order that he may be free to devote himself to higher professional duties. It is advisable that an officer be appointed in every institution to assist the superintendent in the management of these outside departments. In one large hospital this officer is known as the supervisor of buildings and grounds and in another hospital he is known as the business assistant; his special designation is a secondary consideration. It should be possible through him to render effective and harmonious the labors of those connected with the various outside departments. Under his supervision should be the engineer who is responsible for heating and ventilating the hospital, its supply of hot and cold water and its electric light, its ice making and refrigeration, and its general machinery consisting of pumps, laundry machines, elevators and the like. This engineer should be a competent man, understanding fully his various duties, including the use of steam, electricity, refrigeration and ice making, and all minor repairs to the same. Where there are thoughtless patients and careless employes the upkeep of the building cannot be neglected, and all should be committed to a skilful mechanic who is regularly and constantly employed. Painting, varnishing, and glazing should be given to a head painter who usually has enough work to make him a permanent employee. These men should be under the supervisor or business assistant. Under the same officer should be placed the gardeners, laborers, ambulance drivers, etc.; he also should have supervision of fences, roofs, driveways, drains, and sewers. In this department there should be an absolute independence of other departments, with a strict responsibility to the trustees, through the executive officer known as the superintendent.

In the outline given above an attempt has been made to present an organization which will afford the greatest amount of liberty to the individual and, at the same time, the largest and best supervision of the work. It has been found by experience that where regulations governing the operation of any institution are too rigid and unyielding they repel and check an initiative which is essential to progress; hence it is important that every department should be as free as possible to develop in its chosen way. The managing board should seek results, rather than methods and endeavor to secure the best by giving the largest liberty in the execution of the individual plans.

A matter of vital importance to hospital administration is the adequate education of all administra-

tive officers for their responsible duties. It is to be regretted that up to the present time few hospital superintendents have received an adequate education and training for the discharge of duties which require a high degree of business ability and no inconsiderable amount of professional and applied knowledge. Some excellent superintendents have risen by deserved promotion from the business office of the hospital or from the accountant's desk. Others have come from institutions for the insane where for many years men have been trained for analogous duties as assistant physicians. The training, however, thus secured is not always the best because of the special class of patients cared for in such establishments. There may be danger of too rigid ideas of discipline and a failure to appreciate the point of view of the hospital patient who is sane and responsible. Comparatively few superintendents have been trained in general hospitals and the number thus provided is not sufficient to meet the present demand. Other excellent superintendents come from the ranks of successful nurses.

THE HOSPITAL STAFF.—*Heads of Departments.*—Each department of the hospital should be under a skilled chief with a continuous service in order that its work may be done with uniformity and system. In many hospitals in America, and especially those which were organized when physicians and surgeons were largely trained in England, it has been customary to give a divided service to the several heads of the three principal departments. In many hospitals the period of such service has been three months, with a rotation in office bringing a discontinuous service of at least three months and often longer. This has been detrimental to uniformity of work and that excellence which accompanies an undivided responsibility. Upon the Continent of Europe it has been customary to give physicians and surgeons a continuous hospital service and unusual freedom to choose subordinates and assistants. This has promoted growth and development which are impossible when plans of work can only be made for a brief period of from three to six months.

In my judgment it is perferable that the medical care of every department of the hospital should be committed to a responsible head. In the department of medicine there should be a physician-in-chief; in that of surgery, a surgeon-in-chief; in gynecology, a gynecologist-in-chief, whose duties should require them to visit the hospital daily to supervise and direct the work of the department.

Where this continuous service exists it is essential that each department should have a resident medical officer who has had greater experience than the ordinary hospital interne, who generally comes fresh from a medical school without previous experience or training. Such resident physician should have had previous training in medicine or surgery or in whatever branch he may choose to follow as his special work in life.

Resident Medical Staff.—The resident physician should be a man who has had the advantages of at least three years previous hospital training, and should be an expert in physical diagnosis and familiar with the aspects of disease. He should also be competent to follow the different lines of laboratory work which are required by modern methods of medicine. He should have a first hand knowledge of disease at the bedside and be familiar with the use of remedies and the significance of symptoms. It is the duty of such a resident physician to supervise the work of all medical subordinates under the general supervision of the chief physician. His relation to the chief physician should be like that of the family physician to the consultant.

Under the resident physician should be assistant resident physicians, at least one to each ward containing thirty patients. Each assistant resident physician should have immediate charge of the patients of a single ward, and the responsibility of their immediate care. To him should be assigned two internes who may be recent graduates familiar with laboratory methods and physical diagnosis, but with less practical experience. To each interne should be allowed one or more clinical clerks to assist in histories, routine examinations and the usual work of the wards. If at any time an epidemic of serious disease occurs to crowd a ward with an excessive number of very ill patients, additional internes may be needed in order that patients may be watched closely and emergencies may be met promptly should any arise.

Resident Surgical Staff.—The surgical work of the wards should be under the immediate supervision of a resident surgeon who has had at least three years experience in a good hospital after graduating from a medical school. He should have theoretical knowledge and practical experience in surgical operations and be thoroughly trained in surgical work.

He should have general supervision of all surgical patients in the different wards and should make regular daily rounds to ascertain the condition of each patient and to direct and supervise surgical dressings. Subordinate to him should be an assistant resident surgeon in each ward and the latter should have two internes to assist him in routine work as prescribed in the department of medicine. There should be also as many clerks and dressers as may be needed to perform the routine work.

Gynecological Staff.—The assistant in the gynecological department should be known by the title of resident gynecologist and should be a man of experience. In fact he should be prepared for his position by service as interne and assistant resident gynecologist for a period of at least two years. He in turn should be supplied with two or three assistant resident gynecologists, who have had previous service as internes.

There should also be clinical clerks to take histories and to assist in operations and surgical dressings. In view of the close connection between the hospital and the out-patient department, one assistant resident gynecologist should be detailed for daily duty in the dispensary to become familiar with ambulance and emergency cases.

Obstetrical Staff.—There should be one resident obstetrician of large experience residing in the hospital at all times in readiness for obstetrical emergencies. The head of the department should be subject to call in critical cases.

In addition to the resident obstetrician there should be three assistant resident officers, two for service in the lying-in ward or wards and the third to supervise an out-patient obstetrical service which ought to be attached to the obstetrical service of every hospital. There are many expectant mothers who must remain at home during the whole lying-in period to direct the family and keep the household in order, otherwise the domestic machinery may stop abruptly. They are poor and need assistance equally with those women who go to the hospital and they must in many instances be cared for by the department at the home to prevent disaster.

Pediatrics.—The department of pediatrics should also be organized under a competent and responsible head with a resident and assistant residents precisely as the other departments. It is customary in some hospitals to place diseases of children under the care of the department of medicine but such an addition to that department is unwise.

The head of the department should be trained as a pediatrician and devoted wholly to it. In this department it is equally important that a close connection be established with the out-patient service so that children who require hospital care may

be found early and transferred with as little delay as possible to the hospital wards. In pediatrics it is of prime importance to supplement hospital and dispensary work by social service in the homes and families.

Anesthetist.—During the past few years it has become the settled conviction of all hospital managers and officers that important changes need to be made in the interest of the patient in the methods formerly employed in the administration of chloroform, ether, nitrous-oxide and the various forms of local anesthesia. Formerly it was customary for persons who had not received special training to take charge of the administration of an anesthetic during a prolonged and often critical operation, often with disastrous results to the patient or serious detriment to his recovery from the operation because of a lack of skill in giving the anesthetic. It is now generally agreed that every hospital ought to have a regularly appointed, thoroughly competent anesthetist to supervise the giving of chloroform, ether or nitrous-oxide and to instruct and train all persons connected with the hospital who may be called upon to give such service in connection with any anesthetic. He should receive a salary and should devote himself wholly to the work.

Out-patient Department.—An out-patient department is an important factor in medical teaching, and it is important that in the present era of intensive clinical teaching greater attention should be paid to the organization of dispensaries or out-patient departments. Every dispensary should be under a skillful head, a good administrator, preferably a physician, who should be present during the whole dispensary day to provide for the proper registration, distribution, classification and treatment of patients; to arrange to fill the places of members of the staff who are unavoidably absent; to see that the charity of the dispensary is not abused by those who have no right to it and to observe, control and shape the general course of the medical and surgical work.

The following departments are essential to the usefulness of every out-patient department which is concerned in medical teaching and in the instruction of nurses: (1) medicine, (2) surgery, (3) obstetrics, (4) nervous diseases, (5) diseases of women, (6) diseases of children, (7) coordinate branches of surgery, such as orthopedics, genito-urinary surgery, diseases of the nose and throat, diseases of the skin, and diseases of the eye and ear.

Each one of these departments should be under a responsible head who should be present daily, or by a competent assistant to direct the work of his department. It is desirable in certain branches which are associated with ward service that a member of the resident staff of the hospital should attend the dispensary a portion of each day in order that a close connection may be kept up between the out-patient service and the hospital.

Registration of Patients.—In connection with the work of the out-patient department, it is essential that a careful and systematic registration of each patient should be made. This should include all details which are needed for a proper understanding of the disease, which information should be obtained at the time the patient applies for relief, and should be placed on the patient's card immediately. An excellent method is to provide each patient with the facts upon a card to be placed in his hands when he first sees the physician to whose care he is consigned. The patient's number, name and such data as are sufficient for identification also should be placed in his hands to be produced whenever he comes to the dispensary for further treatment. It is of prime importance that at the registration of the patient every effort should be made to ascertain whether the applicant is entitled to free treatment. It is equally important that a careful history of the patient's disease should be obtained when he first applies. Scrupulous care should be taken to record changes in symptoms and the outline of treatment upon each subsequent visit. It is of great importance that as accurate a diagnosis of the patient's disease be made as if he were an occupant of a bed in the hospital. His subsequent history while under treatment should be recorded with equal care. A similar system of record should also indicate what becomes of the patient, and he and his family should be kept under observation through the social service department. It is useless to attempt to treat patients blindly without adequate histories and to dismiss them from treatment without knowing what has been accomplished for them or what has been left undone.

The registration department should exchange lists of patients with other dispensaries in order that the time of physicians and the surgical dressings applied and the remedies used may not be wasted by being duplicated.

It is important that the out-department should have its own definite district of the city, and that patients who apply outside that district should be referred to a dispensary which is more accessible. This requires that a whole city should be districted and served by good dispensaries each under a competent medical staff, and that present careless and unsystematic systems of relief for the sick poor should be corrected.

Each department of the dispensary should be placed under a competent head to whom is given power to select and recommend for appointment all subordinate physicians. He should be made responsible for the work of his department and either himself or a competent representative should be present each day. There should be a surgeon, a physician, an obstetrician, a gynecologist, a pediatrician, etc., each in charge of a department with a competent staff. In no other manner can dispensary work attain proper excellence and efficiency in large cities. Free dispensaries have fallen into disfavor because the medical and surgical work has often been done in a slipshod, unsatisfactory and inconclusive manner. The condition of patients has not been adequately studied owing to an insufficient or incompetent staff, and the supreme effort in many cases seems to have been to complete the work as speedily as possible. It is not a sufficient excuse to say that the amount of work required of the attending staff is far beyond the capacity of any group of individuals to accomplish successfully. If such is the case, and it is unfortunately generally true, more dispensaries should be established with restricted districts, and the staffs of existing dispensaries should be increased to meet all proper demands.

It is sometimes necessary that a small compensation should be given to heads of departments in order that the dispensary may have a right to their time and may require them to give careful systematic and accurate work.

Dispensary Nurses.—Each department of a dispensary should have attached to it one or more nurses to be present at the examination of patients, and to assist in carrying out the directions of physicians. In addition there should be a visiting nurse to visit ambulant cases of accident and disease in their families or homes, and to see that their condition has not changed for the worse through carelessness, ignorance, or willfulness on the part of the patient. The same is true of medical cases; the family should be visited to ascertain the conditions that possibly caused the disease and the actual needs of the patient. In an orthopedic dispensary it is important that a nurse should ascertain at regular intervals by visits, whether the apparatus for the correction of deformities or the relief of a diseased condition, especially in children, is properly adjusted and systematically worn, and to ascertain whether the patient may not be suffering from a maladjusted apparatus or whether

a brace which the patient is wearing may not be doing harm through faulty application.

In the pediatric dispensary the visiting nurse should ascertain whether the sick child has proper food, healthy conditions of living, and careful and judicious management on the part of the family. An obstetric nurse in every dispensary is a necessity. She should visit the mother and infant at regular intervals until her oversight is no longer needed.

The custom at some dispensaries to give surgical treatment to patients or to do minor operations upon the eye, ear, nose or throat, and to send the patient home without any subsequent supervision should be given up. After every operation involving the use of ether or causing any shock to the system, the patient should be kept in a recovery room under the care of a competent nurse, until such time as it is possible for him to go home with safety.

Every dispensary should be provided with an examining room, free from noise and confusion, where the physician can conduct the physical examination of the heart and lungs with a minimum of disturbance and possibility of error.

Careful attention should be given to accident cases and painstaking notes should be taken of the actual conditions present and a detailed history of all operations performed. The presence of contagious diseases should always be looked for whenever a patient comes to the dispensary, and rooms should be provided for the seclusion of all patients who present any symptoms of infectious disease.

General Considerations.—*Registrar.*—It is important that in the hospital and in the out-patient department a registrar be appointed whose duty it shall be to supervise the writing of medical histories and the compilation of statistics. Whenever the records of any hospital are examined it is generally found that the preliminary history is defective and that after a few entries, the subsequent notes are meager, haphazard and without much significance. This is partly due to the fact that the routine treatment of a case is often found to be uninteresting and the attention of the attending physician is necessarily absorbed in other more recent and possibly more interesting cases. For this reason it is necessary to appoint an officer whose duty it is to supervise all histories, and to see that the gaps which frequently occur under such conditions are promptly and regularly filled up. The registrar also should be required to present a summary of the statistics of the hospital and of the dispensary each month, so that the work of the hospital may be known month by month and year by year.

Statistical Tables.—It is of vital importance that statistical tables be made on a definite plan so that the records of each year may be compared, and also that records of one hospital may be compared with another. This requires a uniformity of nomenclature of disease to be used by all institutions. The best nomenclature thus far is the one which was originally prepared for the use of Bellevue Hospital and later revised and corrected by Dr. C. L. Wilbur for the Public Health Service of the United States. Its use should be compulsory in all hospitals.

Of equal importance is a uniformity of methods of tabulating statistics. It is essential that all patients admitted to the hospitals be differentiated by color, sex and conditions and circumstances of discharge, whether they recovered or improved or were discharged to other services, or died, or remained in the hospital at the time that the statistical table was prepared. The tables should show at a glance what disposition has been made of every patient.

Diagrams showing forms of such tabulation are here inserted:

Table I.—White.

Admissions, Discharges, Deaths and Number Remaining in the Different Departments of the Hospital, and Condition on Discharge, for 1913.

Service.	Remaining Jan. 1, 1913.			Admitted.			Total treated.			Discharged			Recovered and improved.			Unimproved.			Not treated.			Transferred.			Died			Remaining Jan. 1, 1914.		
	M	F.	T.	M	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M	F.	T.	M	F.	T.
Medical																														
Surgical																														
Gynecological																														
Obstetrical																														
Total																														

Table II.—White.

Admissions, Discharges and Deaths by Sex and Groups of Ages, for 1913.

	Under 5			5–10			10–15			15–20			20–25			25–35			35–45			45–55			55–65			65–75			Over 75			Total.		
	M	F.	T	M	F	T.	M.	F.	T.	M.	F	T.	M	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.
Remaining Jan. 1, 1913.																																				
Admitted																																				
Discharged																																				
Died																																				
Remaining Jan. 1, 1914.																																				

TABLE III.—MEDICAL DISEASES.—WHITE.

Diagnosis	Remaining Jan 1, 1913			Admitted.			Total treated			Recovered and improved.			Unimproved			Not treated			Transferred			Died			Remaining Jan 1, 1914.		
	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.

TABLE IV.—SURGICAL DISEASES.—WHITE.

Admissions, Discharges, Deaths, Number Remaining, and Condition on Discharge, for 1913

Diagnosis.	Remaining Jan 1, 1913			Admitted.			Total. treated.			Recovered and improved.			Unimproved.			Not treated			Transferred.			Died.			Remaining Jan 1, 1914		
	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.

TABLE V.—GYNECOLOGICAL DISEASES.—WHITE.

Admissions, Discharges, Deaths, Number Remaining, and Condition on Discharge, for 1913.

Diagnosis	Remaining Jan. 1, 1913			Admitted.			Total treated.			Recovered and improved.			Unimproved.			Not treated.			Transferred.			Died.			Remaining Jan. 1, 1914.		
	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.

TABLE VI.—OBSTETRICAL DEPARTMENT.—WHITE.

Admissions, Discharges, Deaths, Number Remaining, and Condition on Discharge, for 1913.

Diagnosis.	Remaining Jan. 1, 1913			Admitted.			Total treated.			Recovered and improved.			Unimproved			Not treated.			Transferred.			Died			Remaining Jan. 1, 1914		
	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.
Labor, spontaneous at term																											
Labor, spontaneous premature.																											
Labor, operative																											
Abortion																											
Admitted post-partum																											
Pregnant, not delivered																											
Not pregnant																											
Total																											

(Corresponding tables should also be made for colored patients.)

These forms enable any person seeking the information, to know how many patients were received suffering from different forms of medical or surgical or other disease; how many recovered, how many died, and how many remained under treatment. By a comparison of such uniform statistics it would be possible to ascertain definitely what the hospitals of the country were accomplishing in treatment of disease and the comparative success of each hospital of the same rank.

LABORATORIES.—The present increasing development of laboratory work in hospitals renders it necessary to speak of a minimum laboratory equipment required by every large public hospital for the proper study and diagnosis of disease. Laboratory work is no longer solely connected with the detailed study of the results of disease revealed at autopsy to determine the point of origin and the course of the morbid process, valuable as such investigation has proven itself to be, but it concerns itself with changes in bodily excretions and secretions, the contents of the blood, the state of the digestive fluids, the presence of parasites, bacteria, protozoa or other morbific agents, the existence of cancer, tuberculosis, syphilis, malaria, plague, etc. To help cure or to palliate disease, these investigations should be made early in its course and treatment by competent observers in well-equipped laboratories.

Pathological Laboratory.—First in order of time pathological laboratories were established in hospitals and trained men were secured to supervise their work. At first most of the studies in such laboratories had to do with the gross appearances found at autopsy. Morbid tissues were observed and described and put away as curiosities in museums. Later as knowledge advanced they began to be studied by means of frozen sections under the microscope and after the tissues had been properly hardened, by similar more permanent sections to ascertain the character and course of the diseased process. Such minute investigation laid the foundation of much of our present knowledge of disease. The lines of investigation, however, soon proved to be so far-reaching it became necessary to discriminate between changes appearing before death and conditions which were found after death. Hence the clinical laboratory was established for the former and the work of the pathologist was restricted to the latter.

The pathological laboratory should be closely con-

nected with a hospital under the charge of a resident physician who devotes his whole time to the work. In some laboratories in addition, the work is supervised and directed by a pathologist of large experience with the title of consulting or visiting pathologist. If the number of autopsies is large it is sometimes advisable to give to the resident pathologist additional assistance. It is important that one pathologist at least should be a resident, as many autopsies need to be done at irregular hours, generally at night, or they may not be done at all. It is also equally essential that the resident pathologist should be in close touch with the clinical aspects of disease among the patients in the hospital before they come to autopsy. There should also be a good bacteriological equipment to facilitate the study of bacterial disease. All autopsies should be carefully recorded in protocols dictated by the pathologist to a stenographer while the autopsy is in progress. These should later be bound and carefully indexed so that the record may be an enduring one. A museum containing gross specimens and cabinets containing sections from hardened tissues are also most essential.

Clinical Laboratory.—For study of disease in the sick prior to an autopsy, a clinical laboratory for the use of the whole hospital is equally necessary. In some of the newer hospitals, small clinical laboratories for individual wards, for general dispensaries and tubercular dispensaries are also provided. There is danger, however, that too much division of laboratories may impair their usefulness and fail to ensure a proper supervision and coordination of their work. Whatever arrangement is made, the work of the clinical laboratory should be under a competent head and supervised and directed along the lines of research as they arise, by the chief physicians of the hospital or the dispensary.

In this laboratory blood examinations should be made; the Wasserman reaction taken; feces, urine and stomach contents examined; diphtheria and similar infections studied; malarial and typhoid fever differentiated and determined; intestinal parasites diagnosticated, tuberculosis, and bacterial diseases studied. It should be the workshop of every hospital interne but the lines of study should be marked out and the work controlled by the physician in charge.

Surgical Laboratory.—The surgical laboratory should be under the direction of the chief surgeon and under the immediate management of a competent histologist and anatomist. Here frozen sections in surgical and gynecological operations should be studied during the operation to determine the nature of a morbid growth and often to determine the character of the operation which ought to be done. Here also every morbid growth should be studied in hardened sections to determine its exact nature. Serial sections should be preserved in convenient cabinets for future study and reference. There should also be provision for the study of body fluids. All pathological specimens should be preserved in a museum. It is of the utmost importance that a careful record be made of all conditions thus determined for future reference.

Organization of Tuberculosis Hospitals.—Hospitals for the treatment of tuberculosis should be under the control of the city, the county or, preferably, the state. They cannot be left to private enterprise or the bounty of philanthropic persons because in their efficient management a certain authority, derived from city ordinances, regulations of boards of health, or acts of the legislature is required. By such authority alone can segregation of the tuberculous patient or efficient supervision of the advanced case be secured. If the tubercular patient is not sometimes compelled to obey the requirements of law and good sense his treatment and segregation will become a farce and he will remain a source of peril to the community. The situation is analogous to that which obtains in the more acute contagious diseases, like smallpox, scarlet fever or diphtheria. Three classes of special hospitals for tuberculosis should be contemplated in every community:

A dispensary for giving diagnosis and skilled advice to incipient cases and a day camp with sleeping porches for use at night.

A hospital for the incipient, acute and presumably curable case, placed in a favorable location with all advantages of climate possible in the State and the added advantages of proper buildings and an adequate and skilled medical staff for the careful daily observation of cases and their treatment.

Hospitals in every city for the care of advanced cases, for the humane treatment of the feeble and helpless consumptive, and for the protection of the community from infection.

The dispensary and day camp should be organized like other dispensaries under a competent medical head with one or more nurses and a corps of visiting nurses to keep in touch at their homes with persons who apply for diagnosis and treatment. Under the medical head should be provided a corps of assistants to attend to the details of individual study and treatment.

The hospital for incipient, acute and hopeful cases should have an organization similar in most respects to a hospital for the insane. There should be a board of trustees appointed by state authority, a superintendent and physician skilled in the diagnosis and treatment of tuberculosis and a corps of able assistants. There should also be a superintendent of nurses, a corps of nurses, a purveyor, matron, housekeeper, engineer, etc.

The hospital for advanced cases should form a department of the municipal hospital or a board of commissioners of charity. For the proper administration of these different institutions adequate authority should be secured by ordinances etc., under the police powers of the State, to detain and classify patients in hospitals, and to supervise and direct their future care when convalescent and able to return to their homes.

Hospitals for Infectious and Contagious Diseases.—The responsibility for the establishment and administration of these hospitals should rest with the city, town, or county to secure the speedy removal of the infectious or contagious case from home and his proper treatment in a convenient hospital adjacent to the city. The former will minimize the danger to his family and lessen the danger of spreading his disease to others while en route to the hospital.

Infectious or contagious hospitals should be directly under the control of the commissioner of health and all medical officers connected with them should be responsible to him. Each hospital should be under the immediate charge of an expert physician who should be skilled in the diagnosis of infectious diseases and to him should be given an ample corps of assistants. He should be responsible for the nursing and care of patients and should be clothed with ample power to enforce whatever regulations may be required for a proper discharge of the duties of his position.

The Government of State and Municipal Hospitals.—*State Hospitals.*—State hospitals are usually governed by commissioners, boards of control or trustees. In some rare instances the governing body is a single commissioner appointed by the governor and confirmed by the senate or governor's council. This arrangement is not a good one because such appointee is commonly a representative of the political body to which the governor belongs and is more often interested in political work than in the elevation of the hospital. In other State hospitals a governing board of three persons is sometimes

appointed to whom is given the responsibility of the management and oversight of State hospitals and charitable and penal institutions. In some of the western states, notably in Minnesota, Iowa, Illinois, and Ohio, such governing bodies are called boards of control. In States where this system of control has been adopted the consensus of opinion is that it has improved the character and quality of institutions for the insane, and has brought them to a uniform standard of excellence. In the State of New York a commission of three, entitled the state hospital commission, has similar charge of all institutions for the insane, fourteen in number, and has unquestionably improved the character of the care of the dependent insane. There is reason to think that in the future an increasingly large proportion of state institutions with a constantly growing resident population, will be governed and controlled in this manner.

Municipal Hospitals.—Municipal hospitals have always constituted a serious problem in hospital management. The majority of them have been under the control of boards of commissioners charged with the relief of the poor and the care of homeless, destitute persons. Their management has generally been conducted through a committee of a board of county commissioners. Being an elective rather than an appointed body, the men who serve as county commissioners as a general rule have had no fitness to cope with the problems which arise and the management of nearly or quite all municipal hospitals has become a matter of shame and disgrace to every city.

During the past few years an effort has been made to meet the situation in such large cities as Boston, New York, Providence, Baltimore, and Cincinnati, by the appointment of boards of trustees consisting of from three to nine members to supervise and manage the affairs of such institutions. In New York the appointments are made from lists of three persons selected by representatives of three prominent religious denominations, the Roman Catholic, Protestant, and Jewish, and from representatives of different charitable societies. The mayor of the city selects one person from the three names submitted and makes the appointment. The terms of service are so arranged that only a minority of the board retires at any one time, as it is desirable that wholesale changes should not occur in the constitution of any board, or in the composition of the resident staff of the hospital.

The Purchase of Supplies.—It is important that each hospital should adopt an annual budget to govern expenditures in each department during the following twelve months. No department should be allowed to incur expenditures beyond the amount set down in the budget except to meet an emergency or because of an unforseen catastrophe, such as an epidemic of disease, a fire, or other similar accidental occurrences. The purchase of supplies should not be hedged about by too many restrictions; large supplies, such as coal, flour, meat, butter and eggs and the heavy groceries should be purchased by sealed proposals or tenders from reliable dealers living in the city if possible. Vegetables, other groceries and similar supplies should be procured directly by a purchasing agent of the hospital to insure good quality and freshness. Gauzes, bandages, drugs, ether, chloroform and chemicals, glass-ware, crockery, bedding and mattresses are best procured through the Bureau of Hospital Supplies, lately organized in the city of New York. All supplies should be furnished to wards or kitchens or storerooms upon requisitions approved by the superintendent or his assistant.

Training School for Nurses.—A training school for nurses having become such an important factor in the success of every large hospital, it seems advisable that a full account be given of its organization and management as a hospital department. The course of training in every first class training school should cover a period of not less than three years, including the preliminary course in various practical branches prior to full acceptance as a pupil nurse. In no other manner is it possible for the nurse to enter the wards adequately prepared to undertake novel and often times responsible duties, the first principles of which she can not know without a preliminary training.

In the best training schools this preliminary course teaches the probationer how to perform various duties in the sick room, such as sweeping, dusting, bed-making, and the handling of the sick person. She should have instruction in the principles of dietetics and the best methods of cooking for the sick. She needs to know the action of remedies, how they are prepared and somewhat of their effects. She requires some knowledge of anatomy, some conception of physiology and such elementary training that she may have an appreciation of the manner in which chemicals are prepared and weighed in order to make solutions, washes and douches of a given strength for external use. She ought to have preliminary instruction in the application of bandages and surgical dressings and the preparation of gauzes and bandages. She must know how clothing is listed and sent to the laundry, and should learn what is to be done with infected clothing to prevent it from becoming a source of contagion to other persons. She needs elementary instruction as to the agency of bacteria in the production of disease so that she may know how to avoid communicating or contracting in her own person diseases like typhoid fever or diphtheria. She requires to learn the mode of action of surgical contagion and how to prevent disease germs from entering wounds and other open cavities during surgical dressings.

When she has thus learned the principles which must govern her service and training as a pupil nurse she will be fitted to begin to discharge simple duties in connection with the actual care of the sick.

Nurses' Building.—It is desirable that a training school for nurses should be housed in a separate and complete building so that it may be self-contained and independent of all other portions of the hospital. It should have its own private class-rooms, recreation rooms, dining-rooms, study room and kitchen. The building should be devoted wholly to the uses of the school and the nurses, and its occupants should be free from the annoyance incident to the presence of persons who have no interest in the school. This arrangement improves and increases the *esprit de corps* of the pupils and removes many causes tending to distract their attention from the proper objects of the school.

Time for Study and Recreation.—In the regulation of the hours of duty due regard should be had to the fact that a training school is an educational as well as a vocational institution, and hours of recreation and study should be provided for as strictly and as carefully as hours of practical work in the wards. It is now generally conceded by those who are interested in educational matters that no nurse should be on active duty more than eight hours out of twenty-four and that her hours should be so arranged as to give a maximum of available service at hours during the day when nurses are most needed in the wards. For this reason it has been customary in many training schools to have pupil nurses on duty discontinuously, for example, from 7 A. M. to 1 P. M., and after an interval of four hours during which the pupil is free to spend the time in study or recreation from 5 to 8 P. M. In other instances the hours may be arranged from 7 until 10 A. M.; from 1 until 4 and from 7 to 9 P. M.

In a few schools an attempt has been made to divide the pupil nurses into three groups, each of which shall be on duty eight hours continuously out

of the twenty-four hours of the day. This arrangement has not been wholly acceptable and probably cannot become general. The night service offers great obstacles to the successful operation of such a schedule of hours. As a rule the hours of the night nurse under the present arrangement of duties must be considered a thing apart from the hours of other pupil nurses. The training of the nurse for night duty is, however, most profitable for her and cannot be given up because it places her upon her own responsibility and gives an opportunity to ascertain her capacity to meet an emergency.

In many instances a pupil nurse seems to discharge her duties extremely well when placed under the supervision, companionship and assistance of a more experienced nurse. When, however, she is given charge as night nurse of a single ward during the night, and must rely upon herself to meet emergencies which may arise in the care of the sick and cannot call upon other assistants, but must use her judgment when to summon the night superintendent or to call for a physician or to exercise the discretion which has been given her in a night order, an opportunity is given to ascertain of what material she is made. Whether or not she is careful, accurate and self-reliant and clearheaded or slipshod and uncertain in whatever she attempts to do will then become manifest. If it were not for the consideration of the proper training of the pupil nurse to meet responsibilities and unusual care, it would be easier, cheaper and more satisfactory for the hospital to employ graduate nurses for night duty. Night service is of great importance to the future nurse and although it is often trying to body and mind, it is requisite to the full training of every nurse.

Curriculum of Study.—The majority of training schools give a course of three years of training divided as follows: During the first six months provision is made for what is known as a preliminary course during which the pupil nurse receives her training in fundamental principles preparatory to assuming the practical duties of nursing. Under a proper system of instruction the pupil nurse should be introduced to a hospital ward by degrees and discharge, at first, comparatively unimportant routine duties under the eye and supervision of a competent nurse. These duties should relate more to methods of caring for patients and to the routine service of the wards and should not, at first, bring a responsibility for the immediate nursing of a particular patient. Many pupil nurses who are interested and proficient in the preliminary course fail when sent out as pupil nurses, generally because they have not been trained to do things. Their education in most instances has been a training of the memory and intellectual faculties without regard to any especial attempt to establish a connection between knowledge and its practical application. The nurse should not only know about nursing but also how to nurse. As Florence Nightingale once said, she should know what to see and how to see, and how to use her senses. She should know what to do and how to do it. Many persons inquire why it is necessary that a pupil nurse should pursue a course of training throughout several years without realizing that her training must become a part of her whole organization until all nursing procedures may by practice become so familiar as to be well-nigh automatic.

There needs to be in connection with the training of each nurse a training in accuracy, carefulness, correctness of thought and good judgment with the development of sober-mindedness and a sense of responsibility.

During the last six months of the first year, the training should be given largely in general nursing, especially the nursing of medical cases and of surgical cases after operations, and the routine care of patients under the direction of an experienced nurse.

During the second year pupil nurses should be placed on night duty, in operating rooms, and should act as assistants in wards and also be engaged in acquiring a knowledge of the care of children and of lying-in-women.

In the third year the time of the nurse should be spent in the work of the dispensary, in learning how to nurse patients in different specialties, and in social service study and work and in those special studies which are required to teach a nurse how to meet the emergencies of institutional nursing, when in the future she may be called upon to deal with training schools, dispensary nursing, school nursing, and other forms of specialized work.

The Organization of the Training School.—A superintendent of nurses should have charge of the school and the responsibility of its management. As intimated before she ought to select pupil nurses and recommend them to the superintendent of the hospital for his approval, and the final recommendation of these two officers should be sent to the trustees of the hospital for their approval.

In a training school of seventy-five to one hundred pupils there ought to be three assistant superintendents, one to be an assistant to the superintendent and to act in her place during her absence, another as assistant in the nurses' home, to have general charge over everything connected with the home. And the third to undertake the scientific branches with the responsibility for the training of pupil nurses in anatomy, physiology, and bacteriology during the preliminary course. There should also be a dietitian in charge of all instruction in food values, cooking for the sick, preparation of sick diets, etc.

Head Nurses as Instructors.—Each ward of the hospital should be supplied with a graduate head nurse whose duty it shall be to supervise and direct the training of pupil nurses. She should be kind, patient and interested in her work and especially in its relations to pupil nurses. The latter often come to ward work with unsatisfactory conceptions as to what nursing may be, and fail to appreciate its true character. Some pupil nurses have a preconceived idea that it is their principal duty to hold the hand of a sick person or to wipe his fevered brow or to sing to him if he is sleepless, and lose sight of the fact that such ministrations to the sick are seldom required outside the pages of fiction. The care of the sick involves personal attention. The patient must be made personally neat and physically comfortable; nourishment needs to be given at regular intervals; remedies must be administered with precision and at the appointed time. Bedding and clothing must be changed with a minimum amount of discomfort to the invalid; the nursing staff and the whole routine of the ward must cooperate to promote the quiet and comfort of each patient. It therefore becomes the duty of the head nurse to coordinate the labors of her assistants, and to bring each pupil into harmony with the spirit of true nursing.

In addition to such ward instruction, there should be similar instruction in surgical operating rooms as to the handling of supplies, the sterilization of dressings, the preparation of a patient for an operation, and the care of sick persons while recovering from anesthesia or the shock following an operation.

In the lying-in ward similar instruction should be given by the head nurse in the preparation of the lying-in patient, and the procedures which are necessary after delivery. The method of handling young infants should be similarly taught, not by precept but by demonstration and example. In the experience of the writer the success of a training school largely depends upon the careful selection of head nurses fitted to give proper instruction to pupil nurses in routine ward work. For this reason it is equally desirable to have trained head nurses not alone in wards and operating rooms, but in dispensaries. In the orthopedic dispensary, a competent

nurse should give instruction in the application of braces, plaster casts, and other orthopedic apparatus, and teach the pupil nurses how to handle sensitive, irritable and intractable children.

In the tuberculosis dispensary similar careful instruction should be given to prevent the possibility of tubercular infection, by methods of disinfecting tubercular sputum, and caring for the tubercular patient in the incipient stages of his disease.

A training school for nurses must always be considered an educational institution, organized on educational lines as a department of the general hospital. The more complete the hospital and the more varied its departments, the greater the opportunities afforded for the instruction of the nurse. There is a tendency to overload the three years period of instruction with a large number of specialties. It is now evident that much special instruction ought to be given in postgraduate schools to such as desire to follow many specialities which cannot be taught in training schools. In New York, Boston, Chicago, Detroit and other large cities, courses of instruction are also now provided for those who desire to become hospital administrators. If they desire to enter upon administrative work graduate nurses should follow such courses in order to become familiar with the problems which arise in the larger work of the administrator. There are also similar courses in schools of philantrophy and in social service which have proven of great assistance to nurses who desire to engage in such work. The care of nervous and deranged patients can also be pursued as a graduate course in connection with several good sanatoriums or psychiatric clinics.

Schools for Orderlies.—Hitherto all attempts to give to men the same efficient training in the care of the sick which has proven so successful in the training of young women have been disappointing. The avenues of employment in the industrial and commercial world are so freely open to men, it has not been practicable to induce them to take systematic training as nurses in any great numbers, or to remain nurses when the training is once secured. This has been noticeably the experience of institutions for the insane where trained male nurses relinquish their positions to become city employes, policemen, sanitary inspectors or department clerks. In building up a permanent body of nurses, training schools for men have proven disappointing. It is, however, necessary to have a class of male nurses known as orderlies, trained in connection with every hospital. Orderlies should receive instruction in handling the sick, and in their ministrations to male patients which cannot with propriety be performed by women nurses. Such special training should occupy from six months to one year, and persons who receive it and who remain in hospital service should be paid an annual increase of salary each year for at least five years, contingent upon remaining in hospital service.

A similar training should be given to nursery and ward maids to ensure a greater degree of efficiency in ward work.

Henry M. Hurd.

Hospital Ships.—The term "hospital ship" may be applied to any ship used as a floating hospital. Under present day usage these hospital ships fall in the following classes.

1. Boats or ships used by municipalities or eleemosynary foundations as floating hospitals: Ships of this character are employed at such coast cities as New York and Boston, their object being not so much the treatment of the sick, as to provide a fresh air outing for the mothers and children of the crowded urban districts, and therefore many elaborate hospital features necessary in a hospital ship depending entirely upon its own resources, as is the case with a military hospital ship, are unnecessary.

2. Boats or ships employed with an industry of the sea: The United States fisheries employ 150,000 persons with an invested capital of nearly $90,000,000. A Revenue cutter has been assigned for hospital duty with the American fisheries, and in the fisheries of Labrador good work has been done along these lines by a combined mission and hospital ship, under the charge of Dr. Grenfell. As many of the civil hospitals of our cities have grown from just this type of church work, it is not improbable that with the increased cost of meat stuffs and the increasing size of the fisheries industry, there will be further and more elaborate development along these lines.

3. Boats and ships employed with armies in connection with oversea expeditions: Ships of this type should be ready early in a campaign across the sea. If they are not ready in good time, hospitals at the base become overcrowded, and a regular system of evacuation of the sick is impossible. Whilst a large proportion of soldiers unfit for further active service in a campaign may be evacuated by transports, a certain percentage of invalids require special accommodations and service, which can only be met by the hospital ship. In the Crimean campaign, for instance, a small fleet of improvised hospital transports evacuated 114,668 patients from the sanitary base. In the South African War ten medical transports or hospital ships were employed in the evacuation of the sick. In the Russo-Japanese war the Japanese employed some eighteen hospital ships for the evacuation of large numbers of sick and wounded.

4. Ships employed by the navy in time of peace, and in time of war: A fleet in time of peace may be likened to a large floating city, of from 15,000 to 20,000 adult persons, employed about machinery, and with many perils of climatic and endemic exposure. A hospital ship in time of peace is not only the development of the humanitarian principle among this large floating population, but serves to preserve more economically the trained man, and return him to his ship rather than leave him in a hospital ashore and thus lose his service for the entire cruise. To use the words of Surgeon General Stokes, the hospital ship is the repair ship for personnel, seeking to maintain the highest degree of military efficiency, and it operates to make the fleet more self-sustaining. In time of war the hospital ship has another function to perform, such as the evacuation of the unfit for service from the fleet, and from the advance sanitary base.

The Hospital Ship for Children and Mothers.—A form of charity has grown up of late in our large cities, which has been directed toward the relief of sick babies whose parents are unable to provide the best air, food, and care for the little ones. The purpose is in most instances directed to benefit the child, and is essentially a children's hospital. Mothers, sisters, and grandmothers, or other persons, are permitted to accompany their charges in most instances. One of the first of this type of institution was founded in New York in 1866. This floating hospital, the *Helen C. Juilliard,* is in charge of the St. John's Guild, and is a barge of 786 gross tons, 202 feet in length. She has a capacity of 1600 patients, and the work is maintained during the summer months of July and August. Women and children only are accepted as patients, and usually for but one day. There is, however, provision to care for bed patients, there being two medical wards. During the year 1913, the ship carried 57,887 beneficiaries. The staff consists of one physician, one matron and chief nurse, and five graduate nurses. The object of the work is to afford relief to the sick children of the poor of New York City, without regard to creed, color or nationality. This activity is supported by voluntary contributions, and an appropriation of $22,500 from New York City. In addition to this institution, supported in part by private benevolence, the Board of Health of New York

Fig. 3234.—The Boston Floating Hospital at Anchor off Boston Light.

Fig. 3235.—Ward for Permanent Patients, Boston Floating Hospital.

City maintains three ferry-boat hospitals, the *Middletown*, *Southfield*, and *Westfield*, day camps of the Bellevue Hospital tuberculosis clinic.

At first an old excursion barge, the *Clifford*, was used. This was replaced by a new boat launched in 1906, and known as the *Boston Floating Hospital*. This is

Fig. 3236.—Deck Ward for Day Patients, Boston Floating Hospital

Fig. 3237.—U. S. Naval Hospital Ship *Solace*.

An elaborate type of this hospital is represented by the *Boston Floating Hospital*. The work was begun in 1904 as the result of the efforts of Mr. R. B. Tobey. a boat of 672 tons, 171 feet in length. The vessel has commodious upper decks, and will accommodate 120 day patients, 120 mothers, and 120 permanent

patients. There are, besides the deck for the day patients, six wards for the permanent patients. For the day patients the ship leaves the wharf in the morning and makes a two hour trip to the day anchorage where the children have a day's benefit of pure air and plenty of sunshine. At 4.30 P.M. the anchor is weighed, and the ship returns to the wharf; at 7.30 P.M. a short trip is made to the night anchorage. For the permanent little patients, who need a longer stay, the best of medical and surgical care is provided. The average length of treatment in these cases is nineteen days. There is a diet kitchen, and facilities for performing operations, if necessary. The professional staff consists of five visiting staff; eleven auxiliary staff; five consulting staff; and twenty

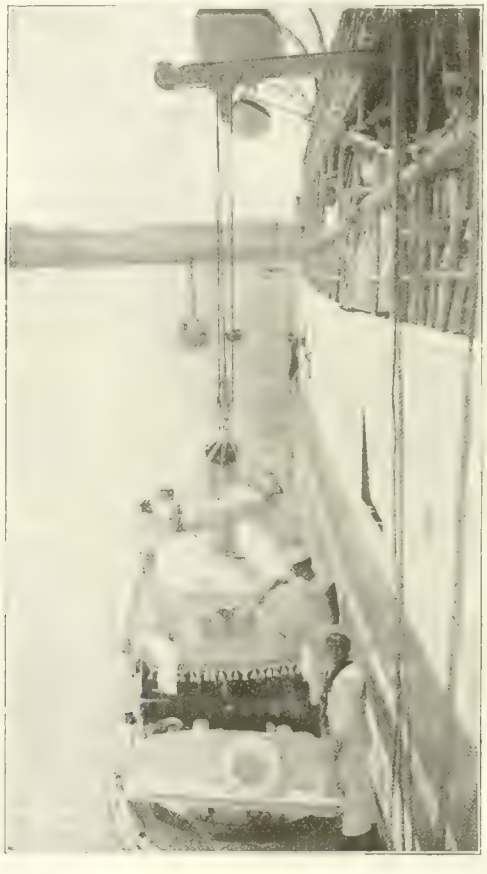


FIG. 3238.—Patient in the Stokes Splint Stretcher being hoisted aboard *Solace*.

house officers and medical students. The nursing staff numbers between sixty and seventy. The activities of the ship continue during the three hot summer months, though the work among the babies continues on shore the year around. Between 18,000 and 20,000 days service is furnished to all classes of beneficiaries.

The object of the effort is well described in the articles of incorporation as follows: "To care for and relieve the sick babies of parents unable to provide the best air, food, care, and medical skill; to make a careful scientific study of the diseases of children, especially those connected with the gastrointestinal tract; to train and instruct medical students, nurses, and mothers in the care and treatment of sick babies."

THE EMPLOYMENT OF HOSPITAL SHIPS WITH FISHING FLEETS.—The value of the world's fishery products, something over $440,000,000, employing a large number of people and a large number of vessels, is little appreciated. The Unites States alone employs over 7,000 vessels in this industry, with a total tonnage of over 200,000. Of the hardships and exposure of those employed in this trade we have obtained some ideas from the writings of Kipling, Connolly, and Grenfell. Of the sorry plight of these people, of their hardships, of their exposure, of their hazard of limb, of the ever present risk of life, we have only a hazy mental picture, and this picture is soon forgotten when we lay aside the book and seek other means of interest. The captain of a small fishing vessel, after working hard for a week or more to obtain bait then at last getting a good berth, finds one of his crew sick. At first the man is treated from the medicine chest, and then as his condition becomes more desperate there is nothing to do but sacrifice the bait, and berth, and head for the nearest port, where the sufferer may be landed, and a new hand shipped. How willingly this sacrifice may be made is left to one's imagination. How often the delay and the neglect result ultimately in the death or chronic invalidism of the victim may be guessed by the human derelicts we find about the fishing ports. I think we may safely estimate an average daily sick rate, in conservative figures, of over two per cent. The unnecessary sacrifice, invalidism, and loss of life would receive considerable mitigation by the presence of a hospital ship.

In 1880, there was founded in England the Royal National Mission to the Deep-sea Fisherman. This organization first sent mission ships into this field where they sought to combat the influence of the floating saloon and public house which catered to the baser instincts of the fisherman. When Sir Frederick Treves was appointed director of the Royal National Mission he visited the fisheries and became convinced of the need of a ship of a medical missionary type, which could minister to the physical as well as the moral needs of this isolated industry. As a result of his efforts a mission ship was equipped with a medical and surgical outfit, and placed in charge of Dr. Grenfell, a young London surgeon, and sailed for the fishing banks. From this first trip Dr. Grenfell returned full of enthusiasm, and this enthusiasm has continued for over twenty-three years, and reflects the greatest credit upon him. With the aid of Treves the first hospital ship for the fleet, the *Queen Victoria*, was fitted out. Since then the work has steadily increased, three additional hospital ships and four dispensary ships having been acquired. In 1901, 12,000 men were treated or carried to home ports.

The dispensary boats are equipped for treating the minor ailments on board the fishing vessels, and serve as ambulance ships to convey the stricken to the shore hospitals or the hospital ship. They carry no doctor, but have in addition to their crew a hospital attendant who has received special instruction in first aid.

The hospital boats vary in size from 100 to 300 tons, and carry a doctor and one or more hospital attendants. They are usually fitted with a consulting room, a ward of six or more beds, a pharmacy, storeroom and frequently a library.

In 1902, Dr. Grenfell carried his work to the coast of Labrador, sailing in the Gospel Hospital Ship *Albert*. The next year he returned to the work with the *Albert*, and a smaller craft, *Princess May*. During this season in company with Dr. Curwen they treated 37 in-patients, 2,493 out-patients, and performed 269 minor operations. Dr. Grenfell gives an interesting description of his first voyage in his book "The Vikings of To-day." Since the days of the *Albert* many ships have been added, such as the *Lord Strathcona*, *Geo. B. Cluett*, and the two yawls, *Yale* and *Andrew J. McCosh*. The *Geo. B. Cluett* was the gift of an American friend interested in this work, while

the two yawls are gifts of American college students, who have recognized the value of this form of charity.

France also maintains an interest in these toilers of the sea, and in 1904, the Society of the Workers of the Sea (Société des Œuvres de Mer) was founded for the purpose of carrying aid to the deep sea fisherman without distinction of nationality. The aid offered is material, mental, medical, and religious. Through the efforts of a retired naval officer, M. Bailley, aided by Admiral Matthieu and Vice Admiral Laffont, the first hospital ship was placed in service in 1896. The society had very unfortunate experiences with its first ships, which goes to show the hazard under which the deep sea fishermen work. The first hospital ship, the *St. Pierre*, was lost on her first trip to the coast of Newfoundland. The next year, 1897, two ships, the *St. Pierre 2nd*, and the *St. Paul*, were equipped, and the former sailed for Newfoundland while the latter sailed for Iceland. The *St. Pierre 2nd*, after rendering valuable aid to the fishing fleet, was damaged by collision on the Grand Banks. The *St. Paul*, after a period of usefulness, ran ashore on the Iceland coast. Both vessels were repaired and returned to their work in 1898 and 1899, but in the latter year the *St. Paul* was wrecked and became a total loss.

In 1900, the society acquired a barkentine of 600 tons, having auxiliary steam power. The next year this vessel, the *St. François d'Assise*, was equipped and cruised in the Newfoundland waters, while the *St. Pierre* patrolled the waters of Iceland. In 1903, in spite of the fact that the French Government had declared these vessels a public utility, and granted a small subsidy, the resources of the society were so depleted that the *St. François d'Assise* was dismantled at Havre. The following year the *St. Pierre* was sold and the *St. François d'Assise* was again placed in service, and since then has gone out each year from May to September to offer succor to deep sea fishermen. Recently the society has obtained an additional vessel.

During the years 1897 to 1907 the hospital ships of the Société des Œuvres de Mer spoke 6,585 fishing vessels, treated 811 patients on board with 12,076 sick days, and held 3,250 consultations at sea. They also rescued 297 shipwrecked sailors, returned 351 convalescents and sick men to France, gave medicines to, or replenished the medicine chests of 1,295 ships, and received or delivered 212,191 letters. According to a recent consular report the *St. François d'Assise*, in 1911, steamed 12,209 marine miles, spoke 1,143 vessels, admitted seventy patients to the hospital, and gave treatment at sea in 420 other cases, besides picking up fourteen ship-wrecked persons.

Fig. 3239.—Animal Yard on Top of the Wheelhouse on the Hospital Ship *Solace*.

The *François d'Assise* is a steel barkentine of 600 tons, about 164 feet long, having a draft of fourteen feet amidships, and under steam power developing about eight knots per hour. She has two decks, weather and berth, and a hold. In a superstructure, forward of the funnel, is the galley and a consulting room. Still farther forward is a disinfecting room.

There are two wards, one an isolation ward of fourteen beds and two hammocks, and a main ward provided with sixteen swinging cots, four hammocks, four stationary couches, giving a total capacity of forty beds for the sick. There is also a dispensary, and a room used by a hospital attendant in which an operating table may be set up if needed.

We have already noted that private charity in the United States has contributed to the work of Dr. Grenfell, but no organized charity has fitted out a vessel to give the helping hand to those of our citizens who labor for our deep sea food. On July 16, 1798, Congress enacted a law making provision for the relief of sick and disabled seamen. The Marine Hospital Service, now the Public Health Service, had its beginning under the operation of this law. Great work has been done by this service, and it may be said that the merchant marine is very well looked after. The Public Health Service has not forgotten the American fishing fleet, which plies its trade in the waters of the North Atlantic, and Congress has recently authorized the adaptation of a revenue cutter for such service. The *Androscoggin*, manned and equipped by the Revenue Cutter Service, but carrying a medical officer, hay-man, and medical supplies from the Public Health Service, is now performing that duty.

Fig. 3240.—Corner of the Chemical Laboratory.

Employment of Hospital Ships for Evacuation of the Sick of Armies.—Hospital ships for the evacuation of the sick or wounded from the advance base in oversea military expeditions have been a part of all the recent expeditions of this kind. Usually these ships have been of a makeshift nature, hastily altered and pressed into service. It is absolutely necessary that the preparations of this kind be made early to prevent the congestion of sick and wounded at the base, with the consequent expenditure of expeditionary supplies and its general demoralizing influence. During the Crimean campaign in 1854, England employed a fleet of vessels, the *Orient, Poictiers, St. Hilda, Clifton, William Jackson,* and others, for the transport of sick and wounded. In twenty-two months 114,668 patients were transferred to the home ports of England. During the campaign in China in 1858, the English employed the *Mauritius* and *Melbourne*. These two steamers were a marked advance over previous hospital transports, and were fitted in a more elaborate manner than those previously employed. The *Victor Emanuel* was converted for hospital purposes in 1873 for service off the Cape Coast. The alterations are said to have cost $200,000, and accommodations were provided for 142 patients.

During the Civil War the United States Army employed several hospital steamers, the most notable of which were the *D. A. January, City of Memphis,* and *Empress*.

During the war with Spain the United States Army

employed four hospital ships, the *Olivette*, *Missouri*, *Relief*, and *Bay State*. The *Missouri* and *Relief* were models of hospital equipment, and performed excellent service during the Spanish-American war and the Philippine insurrection. The *Relief* also rendered service in the Boxer troubles in China in 1900. In 1901 she went out of service as a hospital ship. In 1904 she was transferred to the navy, and after extensive alterations was finally placed in service in 1908, on the occasion of the cruise around the world of the American fleet. She accompanied the fleet as far as the Philippines, and is now used as a floating hospital at the naval station, Olongapo, being no longer regarded as available as a cruising ship. This ship was formerly the *S. S. Roland*, single screw, 3,000 tons, 357 feet in length, 43 feet beam, 24 feet draft, and capable of developing a speed of twelve to fourteen knots. The ship was employed in removing the sick, wounded, and refugees from Salonika to Smyrna. On a single trip the ship would carry 300 to 500 wounded soldiers, and 1,800 to 2,000 refugees.

Spartan also participated in the China campaign of the allied forces on the occasion of the Boxer uprising.

The Japanese with their army during the Russo-Japanese war employed about eighteen ships in the evacuation of their sick, the most notable of which were the Red Cross hospital ships *Hakuia Maru* and *Kosai Maru*. These ships, however, were used more as hospital transports, the trip from the continent to Japan being a short one.

During the recent hostilities between Turkey and the Balkan allies, a Turkish army transport, the *Bahr Ahmar*, was turned over to the Egyptian Red Crescent Mission at Port Said, and in two weeks' time she was repainted and converted into a hospital

Fig. 3241.—Room for Eye and Ear Treatment

hospital ship. The *Relief* has 208 beds including thirty cots in the light infectious ward.

The English army employed several hospital ships during the South African war. The *Maine*, a sister ship of the *Missouri*, had accommodations for 218 patients, operating room, *x*-ray machine, diet kitchen, disinfecting apparatus, refrigerating plant, etc. Her hospital force consisted of six medical officers, five women nurses, eleven male nurses, ten orderlies and two apothecaries. In addition to the *Maine*, the *Princess of Wales*, *Trojan*, and *Spartan*, six additional transports converted at Durban, were utilized for transport of invalids. The *Maine* did good service with the Mediterranean fleet after the war, and was long carried on the British navy list, but has recently been wrecked. The *Princess of Wales*, *Trojan*, and

The Employment of Hospital Ships with Fleets and Naval Expeditions.—The real naval hospital ship as we understand the term is of modern development. As early as 1608, the English employed an auxiliary ship, the *Goodwill*, in the Mediterranean for hospital purposes. The *Dolphin* was with Hood off Toulon in 1793, and the *Pharon* with Howe in 1794, during the battle of the first of June.

The great sea fights of modern times, namely, the battle of Lissa, June 27, 1866, between the Italians and Austrians; the Yalu, Chino-Japanese war; Manila Bay and Santiago, Spanish-American war; and

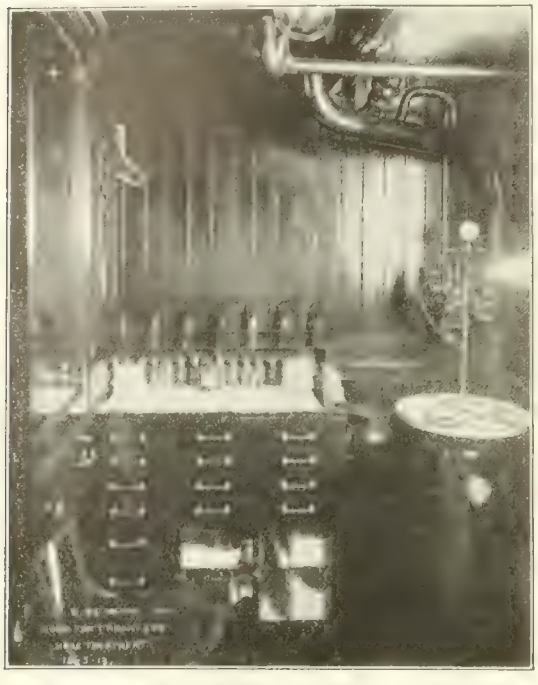


Fig. 3242.—Room for Nose and Throat Treatment

Tsushima, Russo-Japanese war; have been marked by a tremendous loss of life from drowning. In the battle of Lissa the Italians had five killed by gun-fire, while 615 were drowned. In the battle of the Yalu the Chinese lost between 600 and 800. In the battle of Manila Bay 381 were reported as killed, while at Santiago the number was 350. The number in these battles killed outright, and the number drowned is not distinguished. The number of Russians missing, and probably drowned, in the battle of Tsushima has been placed between 5,000 and 8,000. The frightful loss of life from drowning in the modern naval battle has directed a humanitarian influence toward relief for participants in these engagements. The Geneva convention coming soon after the battle of Lissa incorporated articles for relief of participants in marine warfare. The Hague Conference had the record at the Yalu, Manila Bay, Santiago and Tsushima to guide and stimulate further efforts to save wanton waste of lives.

During the Russo-Japanese war the Japanese navy employed two hospital ships, known respectively as the *Saikio Maru* and the *Kobe Maru*. They were both originally merchant vessels belonging to the Nippon Yusen Kaisha. They were sister ships and were both fitted in the same manner. During the Chino-Japanese war, the *Saikio Maru* was converted into a cruiser and took part in the battle of the Yalu. The *Kobe Maru* was used during that war as a hospital ship. After the Chino-Japanese war these ships were returned to the merchant service. On the outbreak of the Russo-Japanese war they were both fitted out as hospital ships. They are single screw steel ships, of 2,978 tons, 365 feet long, 30 feet beam, and of about 20 feet draft. During the war the ships had two large wards, a medical ward of seventy-two bunks and a surgical ward of seventy-eight bunks. Each ship contained sterilizing rooms, laundry, laboratory, operating room, surgical dressing room, *x*-ray room, dispensary, instrument-sharpening room and photographic room.

The Russians during the Russo-Japanese war purchased six large passenger ships varying in size from 5,000 to 12,000 tons. The *Orel*, an 8,000-ton ship, was fitted out and maintained by women of France and Russia. Each defrayed one-half the expense of maintenance. The *Mongolia* was one of the hospital ships fitted out and maintained by the Russian Red Cross. She was a passenger ship of 5,000 tons. The *Nostrome* was a 7,000-ton passenger ship, converted for hospital purposes at one of the ship yards at Shanghai, China.

At the beginning of the hostilities between Italy and Turkey, the Italian Navy Department fitted out two emigrant steamers as ambulance ships. These vessels were the *Re d'Italia*, a ship of 3,982 tons net, and the *Regina d'Italia*, 3,398 tons. In addition to these two steamers the Italian Red Cross Society equipped the steamer *Memfi*. The vessel was chartered by the Italian government, and the Red Cross supplied the medical and surgical equipment and personnel. The Knights of Malta also equipped a vessel, the *Regina Margherita* of 1,981 tons net, and under the same conditions as the Red Cross ship. While these ships were naval hospital ships, it would appear that they were employed mainly in transporting the sick and wounded of the army.

The first hospital ship of the United States Navy was named *Red Rover*, and was assigned to duty with the Mississippi Squadron. She served in this capacity

Fig. 3243.—The Dental Room.

from June 1, 1862, to March 31, 1867, during which period there were admitted 1,697 patients. This ship was commanded by Fleet Surgeon Ninion Pinkney, U. S. Navy, and Acting Master Welles had charge of navigating organization. The ship was regarded as a model in those days, and is described as follows

in a report: "The ice-box of the steamer holds three hundred tons. She has bath-rooms, laundry, elevator for the sick from the lower to the upper deck, amputating room, nine different water closets, gauze blinds to the windows to keep cinders and smoke from annoying the sick, two separate kitchens for sick and well, a regular corps of nurses, and two water closets on every deck." The complement of medical officers varied from time to time, but in the main averaged three. A squadron order directed that only the seriously sick be sent to her for treatment.

During the Spanish-American war the United States purchased from the Morgan Line the steamer *Creole*, 5,700 tons displacement, single screw, and of fifteen knots speed. This ship was converted into an ambulance or hospital ship by the Navy, and commissioned under the name *Solace*. She rendered signal service after the naval engagement off Santiago. After the war with Spain she was used as a transport.

In November, 1909, after an extensive overhauling, she was again placed in service as a hospital ship, and assigned to duty with the Atlantic Fleet. This ship is probably one of the best equipped hospital ships of modern times. The ship is under the command of a medical officer of the navy, and the professional complement consists of six medical officers, a pharmacist and fifty-two hospital-corps men. The complement from the Naval Auxiliary Service comprises eleven officers and seventy-one men.

The quarters for the commanding officer, the sailing master, and the watch officers are on the hurricane deck, forward. Aft on this deck are three isolation wards with a total capacity of thirty patients. On the upper deck from forward aft is the operating room with two operating tables, the eye, ear, nose, and throat examining room, the laboratory, dental laboratory, medical officers' mess room, galleys, auxiliary officers' mess rooms, officers' staterooms, office of the medical officer of the day, rooms for nine officer patients, the convalescents' mess room, and a lavatory for the hospital corps. On the main deck, forward, are the two main wards with double tiers of bunks, accommodating sixty-eight patients in the medical and seventy-six in the surgical ward. The remaining portion of this deck is assigned to the berth-

Fig. 3244.—The X-ray Room.

ing and messing of the engineer's force, the mess attendants, and the hospital-corps men. On the lower deck, forward, are the seamen's quarters; the storerooms and machinery occupying the remaining space.

In the extreme after end is the morgue, which is cooled by circulating brine from the ice plant. There has recently been installed a diet kitchen provided with electric appliances for cooking. It is unnecessary to itemize the equipment of the hospital, which is thoroughly modern in all respects.

A wireless outfit is of great use for communication with the fleet at a distance.

The methods of handling patients have been worked out, the Stokes splint stretcher being generally used. Extension cranes with trolleys and automatic locking

hooks have been adopted for transferring patients from boats to the upper deck. An elevator provides for easy transit from the ward to the operating room and upper deck. The *Solace* has had the reputation of rolling excessively during former commissionings, but it is now reported as being quite stable, due to a change in the amount of ballast and the addition of bilge keels.

Several modern navies now maintain or carry on their lists hospital ships; England has the *Carolina* and the *Mercator*, formerly the *Heliopolis;* Germany employed the Hamburg American liner *Hansa* in the maneuvers in 1909; Austria has the *Achille, Almissa* and *Maria Theresa;* Japan has the *Hakuai Maru* and *Kosai Maru;* and the United States has the *Solace*.

The Neutrality of a Hospital Ship.—In time of war the hospital ship has a definite status of neutrality between powers signatory to the Geneva Convention or any one or all of the conventions or conferences which followed, and which sought to adapt the provisions of the Geneva convention to maritime warfare.

The following is a list of the instruments in the preparation of which the United States was represented:

1. The Geneva Convention concluded August 22, 1864.

2. The Hague Peace Conference of July 29, 1899.

3. Convention between certain powers regarding the exemption of hospital ships, in time of war, from the payment of all dues and taxes imposed for the benefit of the State, signed at the Hague, December 21, 1904.

4. Hague convention of October 18, 1907, for the adaptation of the principles of the Geneva convention of July 6, 1906, to maritime warfare.

The latter convention was proclaimed by the President August 2, 1910, and will probably be adhered to by the United States in event of a war even with a power that has not officially ratified the convention. Mutual agreements between belligerents who had not officially ratified one of these conventions occurred in the Crimean, Franco-Prussian, Chilian-Peruvian, and Spanish-American wars. For instance, in the latter war the United States notified Spain of her intent to use the *Solace* as an ambulance ship and thereby signified her purpose to adhere to the principles of the Geneva Convention of 1868, notwithstanding that this government had not officially ratified that convention. The convention of 1907 has now achieved ratification by the principal naval powers, and it is the articles of this convention which follow:

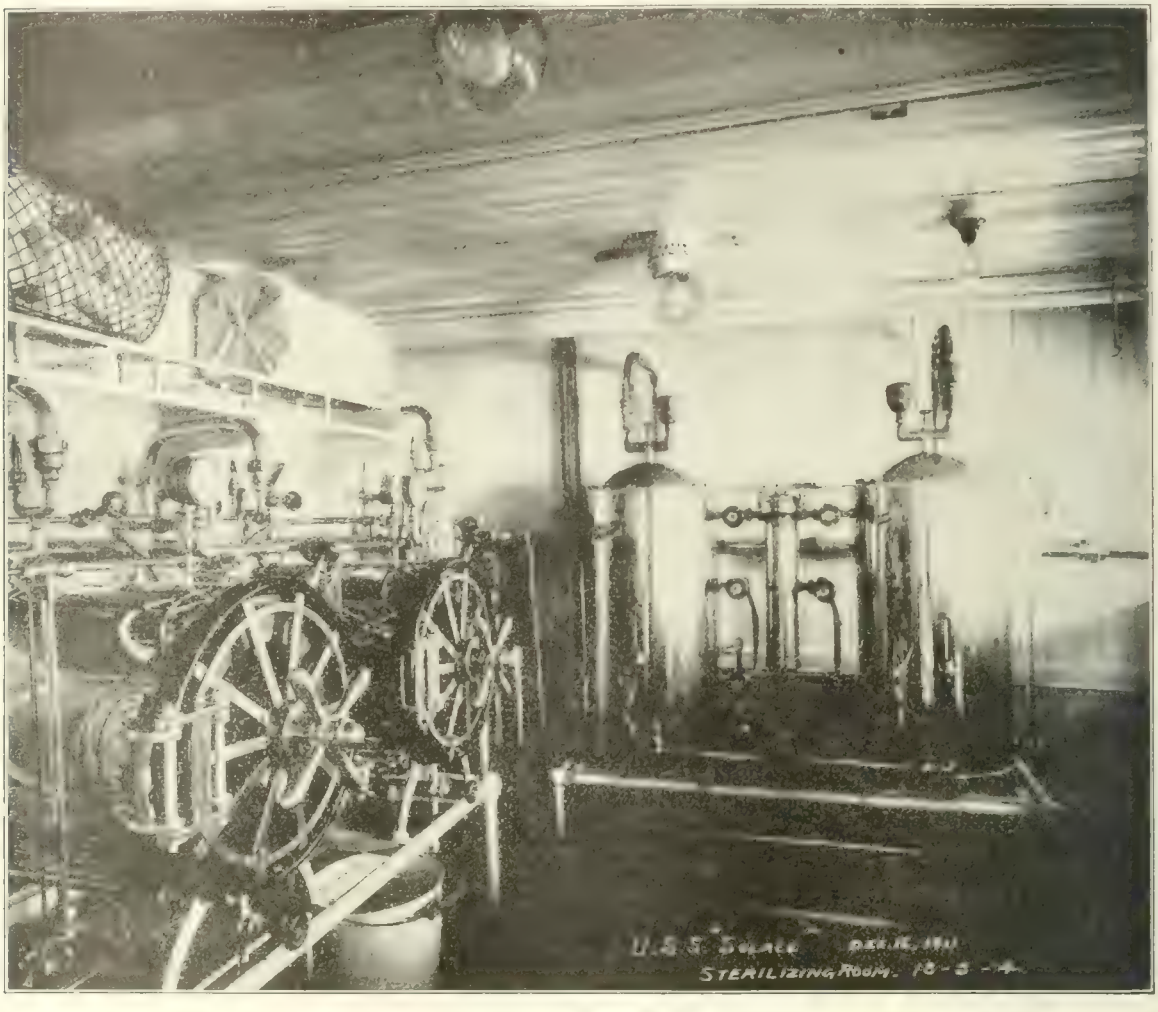


Fig. 3215.—Sterilizing Room.

HAGUE CONVENTION OF OCTOBER 18, 1907, FOR THE ADAPTATION OF THE PRINCIPLES OF THE GENEVA CONVENTION OF JULY 6, 1906, TO MARITIME WARFARE.

Article 1.—Military hospital ships, that is to say, ships constructed or assigned by States specially and solely with a view to assisting the wounded, sick, and shipwrecked, the names of which have been communicated to the belligerent Powers at the commencement of or during the course of hostilities, and in any case before they are employed, shall be respected, and cannot be captured while hostilities last.

These ships, moreover, are not on the same footing as warships as regards their stay in neutral port.

Article 2.—Hospital ships, equipped wholly or in part at the expense of private individuals or officially recognized relief societies, shall be likewise respected and exempt from capture, if the belligerent Power to whom they belong has given them an official commission and has notified their names to the hostile Power at the commencement of or during hostilities, and in any case before they are employed.

These ships must be provided with a certificate from the competent authorities declaring that the vessels have been under their control while fitting out and on final departure.

Article 3.—Hospital ships, equipped wholly or in part at the expense of private individuals or officially recognized societies of neutral countries, shall be respected and exempt from capture, on condition that they are placed under the control of one of the belligerents, with the previous consent of their own Government and with the authorization of the belligerent himself, and that the latter has notified their name to his adversary at the commencement of or during hostilities, and in any case, before they are employed.

Article 4.—The ships mentioned in Articles 1, 2 and 3 shall afford relief and assistance to the wounded, sick and, shipwrecked of the belligerents without distinction of nationality.

The Governments undertake not to use these ships for any military purpose.

These vessels must in no wise hamper the movements of the combatants.

During and after an engagement they will act at their own risk and peril.

The belligerents shall have the right to control and search them; they can refuse to help them, order them off, make them take a certain course, and put a Commissioner on board, they can even detain them, if important circumstances require it.

As far as possible, the belligerents shall enter in the log of the hospital ships the orders which they give them.

Article 5.—Military hospital ships shall be distinguished by being painted white outside with a horizontal band of green about a meter and a half in breadth.

The ships mentioned in Articles 2 and 3 shall be distinguished by being painted white outside with a horizontal band of red about a meter and a half in breadth.

The boats of the ships above mentioned, as also small craft which may be used for hospital work, shall be distinguished by similar painting.

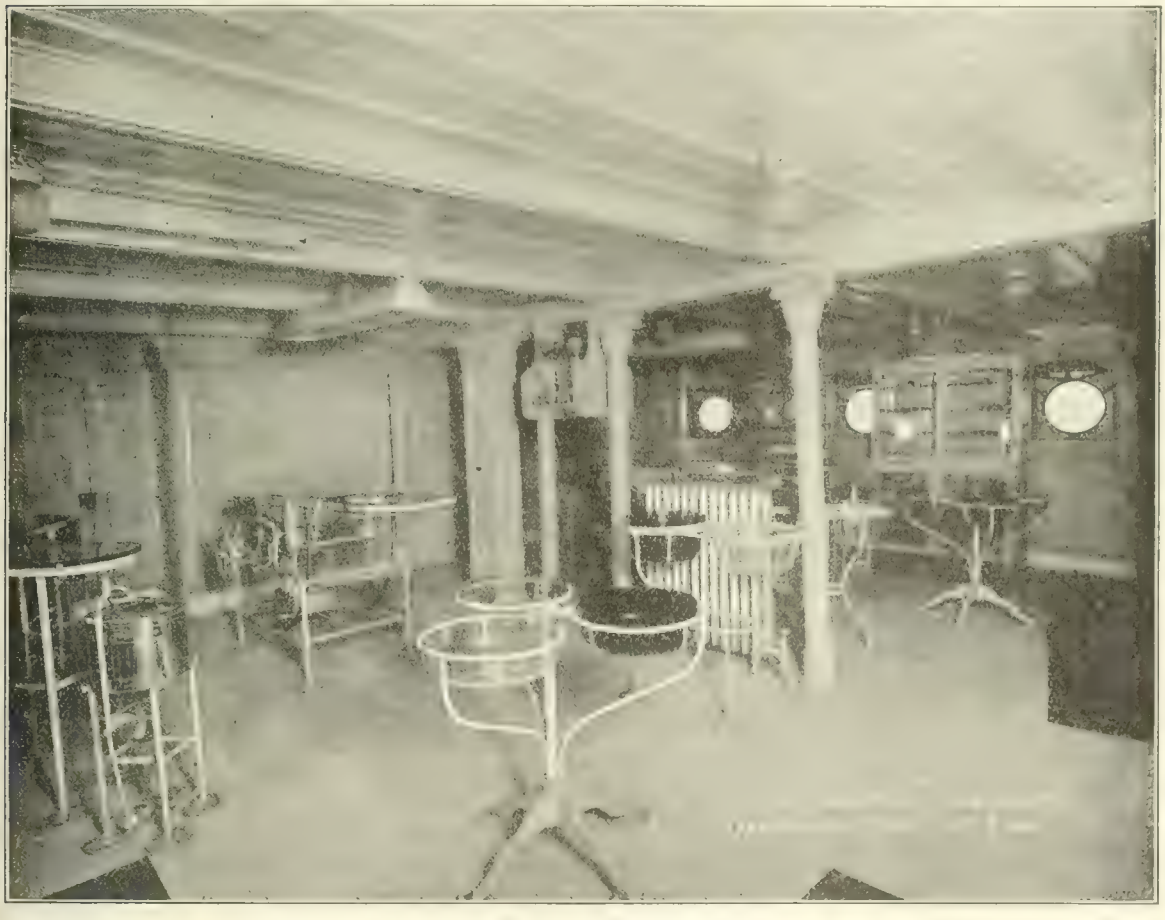


Fig. 3246.—Operating Room.

All hospital ships shall make themselves known by hoisting with their national flag, the white flag with a red cross provided by the Geneva Convention, and further, if they belong to a neutral State, by flying at the mainmast the national flag of the belligerent under whose control they are placed.

Hospital ships which, in the terms of Article 4, are detained by the enemy, must haul down the national flag of the belligerent to whom they belong.

The ships and boats above mentioned which wish to ensure by night the freedom from interference to which they are entitled, must, subject to the assent of the belligerent they are accompanying, take the necessary measures to render their special painting sufficiently plain.

Article 6.—The distinguishing signs referred to in Article 5 can only be used whether in time of peace or war, for protecting or indicating the ships therein mentioned.

Article 7.—In the case of a fight on board a war-ship, the sick-wards shall be respected and spared as far as possible.

The said sick-wards and the material belonging to them remain subject to the laws of war; they cannot, however, be used for any purpose other than that for which they were originally intended, so long as they are required for the sick and wounded.

The commander, however, into whose power they have fallen may apply them to other purposes, if the military situation requires it, after seeing that the sick and wounded on board are properly provided for.

Article 8.—Hospital ships and sick-wards of vessels are no longer entitled to protection if they are employed for the purpose of injuring the enemy.

The fact of the staff of the said ships and sick-wards being armed for maintaining order and for defending the sick and wounded, and as well as other persons officially attached to fleets or armies, whatever their nationality, shall be respected and tended by the captors.

Article 12.—Any war-ship belonging to a belligerent may demand that sick, wounded, or shipwrecked men on board military hospital ships, hospital ships belonging to relief societies or to private individuals, merchant ships, yachts, or boats, whatever the nationality of these vessels, should be handed over.

Article 13.—If sick, wounded, or shipwrecked persons are taken on board a neutral war-ship, every possible precaution must be taken that they do not again take part in the operations of the war.

Article 14.—The shipwrecked, wounded, or sick of one of the belligerents who fall into the power of the other belligerent are prisoners of war. The captor must decide, according to the circumstances, whether to keep them, send them to a port of his

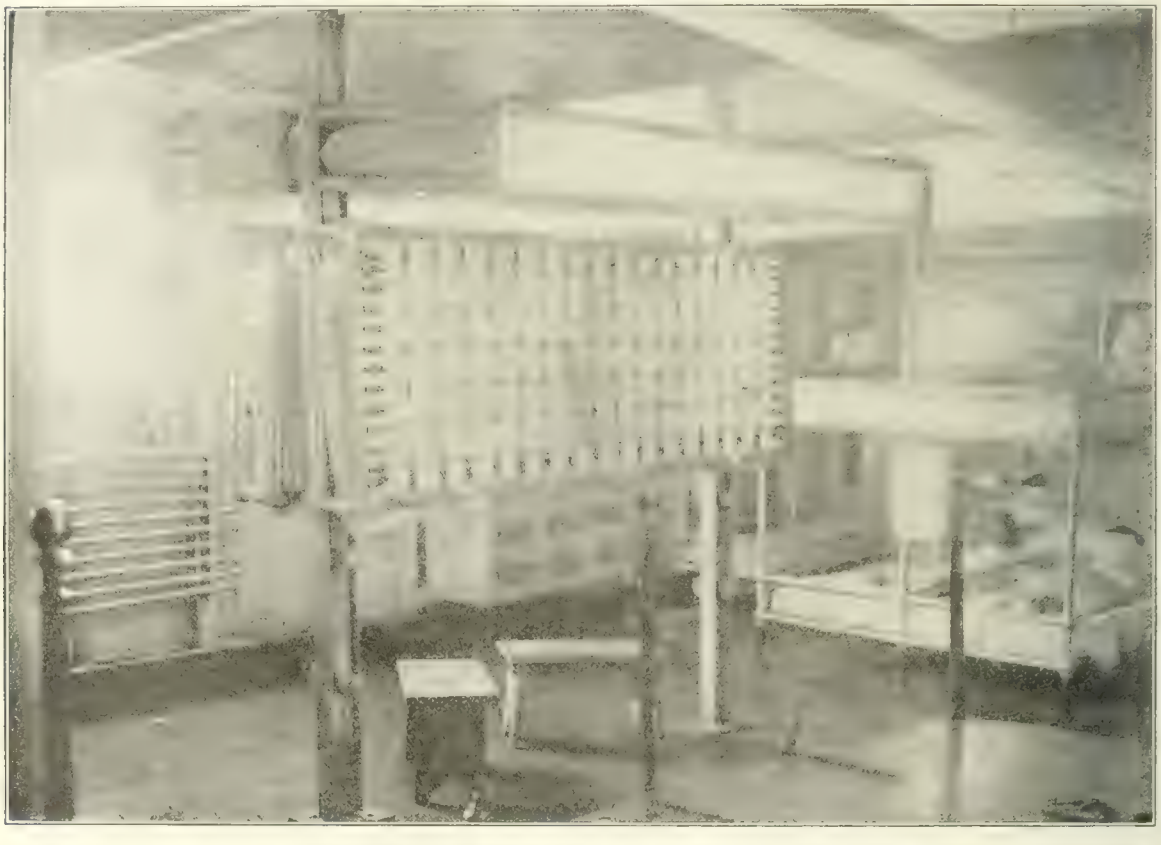


Fig. 3247.—A Corner of Ward showing Stationary and Removable Types of Bunks.

the presence of wireless telegraphy apparatus on board, is not a sufficient reason for withdrawing protection.

Article 9.—Belligerents may appeal to the charity of the commanders of neutral merchant ships, yachts, or boats to take on board and tend the sick and wounded.

Vessels responding to this appeal, and also vessels which have of their own accord rescued sick, wounded, or shipwrecked men, shall enjoy special protection and certain immunities. In no case can they be captured for having such persons on board, but, apart from special undertakings that have been made to them, they remain liable to capture for any violations of neutrality they may have committed.

Article 10.—The religious, medical, and hospital staff of any captured ship is inviolable, and its members cannot be made prisoners of war. On leaving the ship they take away with them the objects and surgical instruments which are their own private property.

This staff shall continue to discharge its duties while necessary, and can afterward leave, when the Commander-in-chief considers it possible.

The belligerents must guarantee to the said staff, when it has fallen into their hands, the same allowances and pay which are given to the staff of corresponding rank in their own navy.

Article 11.—Sailors and soldiers on board, when sick or wounded, own country, to a neutral port, or even to an enemy port. In this last case, prisoners thus repatriated cannot serve again while the war lasts.

Article 15.—The shipwrecked, sick, or wounded, who are landed at a neutral port with the consent of the local authorities, must, unless an arrangement is made to the contrary between the neutral State and the belligerent States, be guarded by the neutral State so as to prevent their again taking part in the operations of the war.

The expenses of tending them in hospital and interning them shall be borne by the State to which the shipwrecked, sick, or wounded persons belong.

Article 16.—After every engagement, the two belligerents, so far as military interests permit, shall take steps to look for the shipwrecked, sick, and wounded, and to protect them, as well as the dead, against pillage and ill-treatment.

They shall see that the burial, whether by land or sea, or cremation of the dead shall be preceded by a careful examination of the corpse.

Article 17.—Each belligerent shall send, as early as possible, to the authorities of their country, Navy, or Army, the military marks or documents of identity found on the dead and the description of the sick and wounded picked up by him.

The belligerents shall keep each other informed as to internments and transfers as well as to the admissions into hospital and deaths

which have occurred among the sick and wounded in their hands. They shall collect all the objects of personal use, valuables, letters, etc., which are found in the captured ships, or which have been left by the sick or wounded who died in hospital, in order to have them forwarded to the persons concerned by the authorities of their own country.

Article 18.—The provisions of the present Convention do not apply except between Contracting Powers, and then only if all the belligerents are parties to the Convention.

Article 19.—The Commanders-in-chief of the belligerent fleets must see that the above Articles are properly carried out; they will have also to see to cases not covered thereby, in accordance with the instructions of their respective Governments and in conformity with the general principles of the present Convention.

Article 20.—The Signatory Powers shall take the necessary measures for bringing the provisions of the present Convention to the knowledge of their naval forces, and especially of the members entitled thereunder to immunity, and for making them known to the public.

The first deposit of ratifications shall be recorded in a proces-verbal signed by the Representatives of the Powers taking part therein and by the Netherlands Minister for Foreign Affairs.

Subsequent deposits of ratifications shall be made by means of a written notification addressed to the Netherlands Government and accompanied by the instrument of ratification.

A certified copy of the proces-verbal relative to the first deposit of ratifications, of the notifications mentioned in the preceding paragraph, as well as of the instruments of ratification, shall be at once sent by the Netherlands Government through the diplomatic channel to the Powers invited to the Second Peace Conference, as well as to the other Powers which have adhered to the Convention. In the cases contemplated in the preceding paragraph the said Government shall inform them at the same time of the date on which it received the notification.

Article 24.—Non-Signatory Powers which have accepted the Geneva Convention of the 6th of July, 1906, may adhere to the present Convention.

The Power which desires to adhere notifies its intention to the

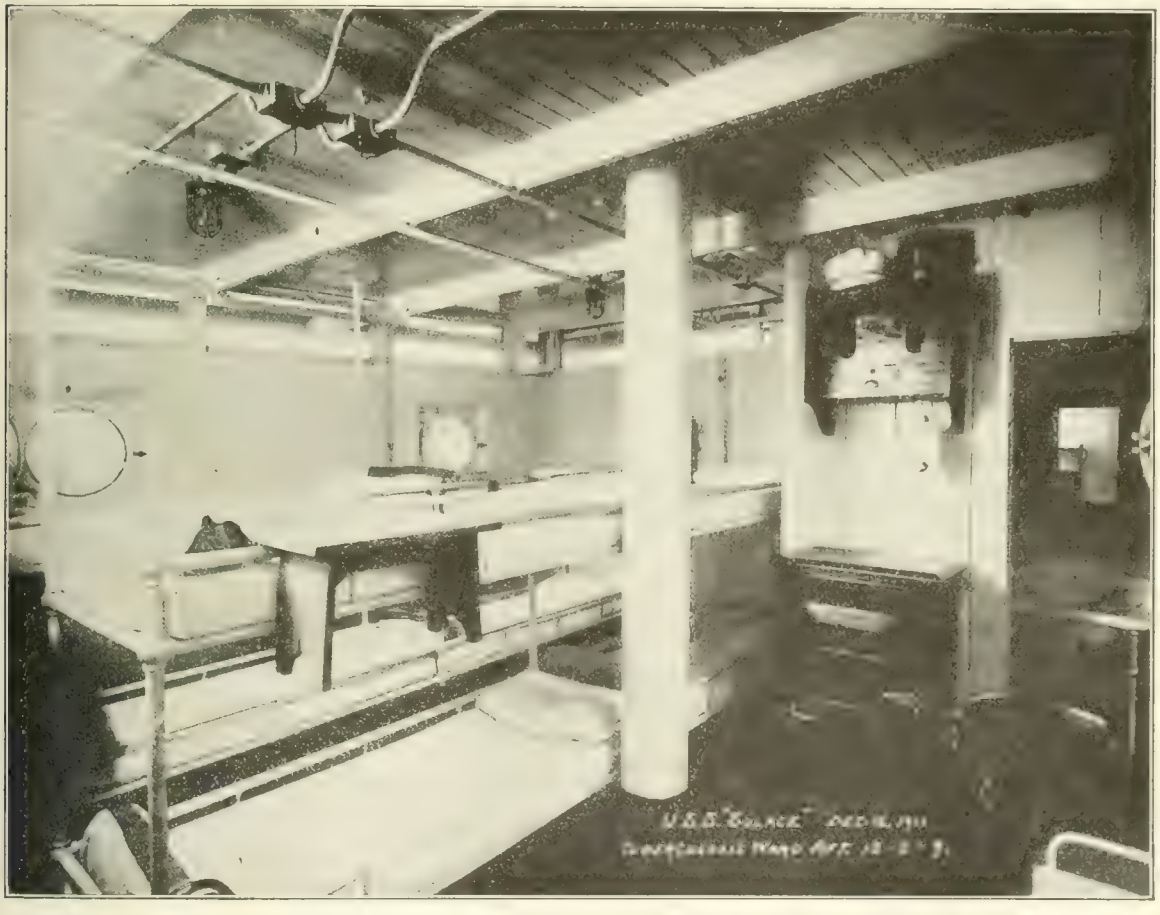


Fig. 3248.—An Isolation Ward for Tuberculous Patients.

Article 21.—The Signatory Powers likewise undertake to enact or to propose to their Legislatures, if their criminal laws are inadequate, the measures necessary for checking in time of war individual acts of pillage and ill-treatment in respect to the sick and wounded in the fleet, as well as for punishing, as an unjustifiable adoption of naval or military marks, the unauthorized use of the distinctive marks mentioned in Article 5 by vessels not protected by the present Convention.

They will communicate to each other, through the Netherlands Government, the enactments for preventing such acts at the latest within five years of the ratification of the present Convention.

Article 22.—In the case of operations of war between the land and sea forces of belligerents, the provisions of the present Convention do not apply except between the forces actually on board ship.

Article 23.—The present Convention shall be ratified as soon as possible.

The ratifications shall be deposited at The Hague.

Netherlands Government in writing, forwarding to it the act of adhesion, which shall be deposited in the archives of the said Government.

The said Government shall at once transmit to all the other Powers a duly certified copy of the notification as well as of the act of adhesion, mentioning the date on which it received the notification.

Article 25.—The present Convention, duly ratified, shall replace as between Contracting Powers, the Convention of 29th of July, 1899, for the adaptation to maritime warfare of the principles of the Geneva Convention.

The Convention of 1899 remains in force as between the Powers which signed it but which do not also ratify the present Convention.

Article 26.—The present Convention shall come into force, in the case of the Powers which were a party to the first deposit of ratifications, sixty days after the date of the proces-verbal of this deposit, and, in the case of the Powers which ratify subsequently

or which adhere, sixty days after the notification of their ratification or of their adhesion has been received by the Netherlands Government.

Article 27.—In the event of one of the Contracting Powers wishing to denounce the present Convention, the denunciation shall be notified in writing to the Netherlands Government, which shall at once communicate a duly certified copy of the notification to all the other powers, informing them at the same time of the date on which it was received.

The denunciation shall only have effect in regard to the notifying Power, and one year after the notification has reached the Netherlands Government.

Article 28.—A register kept by the Netherlands Ministry for Foreign Affairs shall give the date of the deposit of ratifications made in virtue of Article 23, paragraphs 3 and 4, as well as the date on which the notifications of adhesion (Article 24, paragraph 2) or of denunciation (Article 27, paragraph 1) have been received.

Each contracting party is entitled to have access to this register and to be supplied with duly certified extracts from it.

In faith whereof the Plenipotentiaries have appended their signatures to the present convention.

Done at The Hague, the 18th of October, 1907, in a single copy, which shall remain deposited in the archives of the Netherland Government, and duly certified copies of which shall be sent, through the diplomatic channel, to the Powers which have been invited to the Second Peace Conference.

The first three articles of this convention, it may be seen, divide these, the hospital ships, into two classes. (1) The military hospital ship. (2) The non-military hospital ship, which class is again subdivided into ships equipped from benevolent sources under a belligerent, and ships equipped from benevolent sources under a non-belligerent. The *Solace* and the *Relief*, equipped respectively by the Navy and Army during the Spanish-American war, are memorable examples of the military hospital ships, while the *Maine*, as employed in the Boer war, was a non-military hospital ship.

In Article 4 it is stipulated that the governments shall undertake not to use these ships for military purposes. An incident in the Russo-Japanese war will serve to indicate what has been interpreted to be a violation of this provision. The Japanese seized and condemned by prize-court procedure the Russian hospital ship *Orel*, on the ground that there was evidence to indicate she had been employed under conditions construed to be of a military nature. There was evidence to show that she had been employed to carry official messages; that her services had been utilized to make purchases of military material; that the crew of the *Oldhamia*, a captured prize, had been placed on board of her, and further it was shown that with the *Kostroma*, another Russian hospital ship in Admiral Nebogatoff's division, she had been assigned a place in advance of the Russian main body, a place usually assigned a scouting vessel. This evidence led to the condemnation and confiscation of the *Orel*, and her being renamed the *Kusuho Maru*. The article further provides that the hospital ship, during an engagement, shall act at its own risk and peril. Thus the Russian hospital ship *Angara* was sunk by shell during the bombardment of the fortress at Port Arthur.

Article 5 provides for the distinctive marks of the military and the non-military hospital ship. The military hospital ship is designated by a green strake about her hull, while the non-military hospital ship is designated by a red strake. The Red Cross flag is flown by most countries, but the Turkish and Persian delegates reserved the right to replace the Red Cross by the Red Crescent and Red Lión respectively. During the recent hostilities in the Balkans the Egyptian Red Crescent Mission employed a hospital ship, *Bahr Ahram*, under the Red Crescent flag. Siam places beside the red cross an emblem sacred to the Buddhist religion, also in red, and called "The Flame." Other distinctions are adopted by some countries which would help to distinguish the character of the ship at night. The Japanese, Russian, and also some other nations, paint the Red Cross on the smoke stack so that a search light may be thrown upon it at night. The United States Navy has now adopted this, and in addition provides for its illumination at night by an outline of electric lights when necessary to make itself known.

Article 8, in guarded terms, states that the presence of wireless telegraphy apparatus on board is not sufficient reason to withdraw protection. A hospital ship should use no secret code, and the U. S. Navy Regulations provide that in flag signals only the international code may be used. One of the charges made against the *Orel*, captured in the battle of Tsushima, May, 1905, is said to have been the fact that she had a wireless apparatus aboard. At the next convention, in 1907, the Dutch delegate proposed the exemption which now appears in the articles of the convention of 1907.

The Command of Hospital Ships.—Most countries are now placing the command of hospital ships under medical officers. The *Solace* during the war with Spain was under the command of an officer of the line. Many criticisms have been made of this ship's violation of neutrality provisions at that time.

During the early part of the war between Russia and Japan, the Japanese naval hospital ships were placed under the command of officers of the line, but later these officers were withdrawn and the ships placed under the command of medical officers. Director General Saneyoshi in a communication to Surgeon General Braisted wrote: "We used officers of the line in addition to the civilian captains and crew on hospital ships, but we removed the combatants for three reasons: (1) because there might be some dispute as to the Hague agreement; (2) because naval officers and men might be short and needed; (3) we could not use a cipher code on the hospital ships, but the universal signaling code, so that there is no special necessity for naval men."

In 1904, when the *Relief* was made ready for commissioning a bitter controversy arose over the placing of a medical officer in command. The then chief of the Bureau of Navigation was adverse to placing a medical officer in command. The question was then settled by President Roosevelt, who in a letter to the Secretary of the Navy, dated January 4, 1908, said in part:

"Military surgeons, including naval surgeons, have special knowledge of hospital ships, and they have in addition certain military duties of command, organization drills and discipline just as do officers of the line, awarding punishments, and being guided and governed in these military duties by the same regulations that guide and govern officers of the line. The command of a hospital ship should unquestionably be vested in a medical officer, and no line officer should be aboard it.

"In time of war the presence of combatants—that is, of line officers or crew—would certainly cast a suspicion upon the neutrality of the ship; and no line officer worth his salt would wish to be on such a ship, while it seems incredible that any line officer should desire to have another line officer on board such a ship. Hospitals, afloat or ashore, should no more be under the command of line officers than regiments or warships should be under the command of surgeons; one kind of appointment is quite as inappropriate as the other.

"Hospital ships should be maintained in time of peace exactly under the same conditions as in time of war. The system has been tried in the Army and tried in foreign navies, and has worked without a hitch. It is the only system that should be tolerated; and if it fails to work well, this failure can only be due to lack of desire to have it work well on the part of those concerned.

"I direct that unless Congress provides otherwise, the practice in the Navy be assimilated to that now obtaining in the Army. In the Army the hospital

ship is treated as a general hospital, and article 1467 reads as follows: General hospitals will be under the exclusive control of the surgeon-general and will be governed by such regulations as the Secretary of War may prescribe. The senior surgeon will command the same."

It is doubtful if any country will again place a combatant officer in command of a hospital ship. England, in 1913, granted the command of the large naval hospitals abroad, as well as at home, to the medical officers, and it is reasonable to assume that the command of the hospital ship will also be placed wholly in the hands of a medical officer.

ARMY AND NAVY REGULATIONS GOVERNING HOSPITAL SHIPS.—The navy regulations provide as follows for hospital ships, their organization, employment, and neutrality:

2911. The Navy Department shall designate such vessels as it may deem necessary to be called and employed as "hospital ships." When in service, such ships shall be considered as floating hospitals, for the purpose of caring for, treating, and transporting the sick and wounded of the Navy, Marine Corps, and Army, as well as shipwrecked and other persons requiring medical service; and as such, shall be under the general direction of the Bureau of Medicine and Surgery, so far as all matters pertaining to the distinctly hospital features of the ship are concerned. Action in regard to such matters pertaining to the distinctly hospital features of the ship, and in regard to the detail of medical officers and members of the Hospital Corps thereto, shall be upon the recommendation of the Bureau of Medicine and Surgery. Action in regard to matters not pertaining to the distinctly hospital features of the ship shall be taken by the appropriate bureaus or offices of the department in the same manner as is done for any other ship of the auxiliary service.

2912.—No persons other than those enumerated in the preceding article shall be transported aboard hospital ships.

2913. Hospital ships shall be governed by the provisions of the Navy Regulations and Naval Instructions, so far as they apply, of the laws of the United States, and of the Hague Convention of October 18, 1907, making applicable to such ships the principles of the Geneva Convention of July 29, 1899.

2914. A hospital ship, being assimilated to a naval hospital on shore, shall be commanded by a naval medical officer not below the grade of surgeon, such commanding officer being detailed by the Navy Department. Such vessels shall be manned by a merchant crew and officers, and, in addition, by a detail from the Hospital Corps of the Navy, the latter to be employed in carrying out the duties for which the vessel is especially assigned.

2915. Hospital ships shall be regarded as naval auxiliary vessels, and, as such, shall be subject to the inspection, care, and supervision of the supervisor of naval auxiliaries, so far as concerns the non-medical portion of the ship. That officer shall also be responsible for the management and security of all property on board not under the medical department.

2916. All hospital ships shall be distinguished by being painted white outside, with a horizontal band of green about a meter and a half in breadth. The boats of hospital ships shall be distinguished by similar painting. In accordance with the terms of the Geneva Convention, every hospital ship shall fly the Geneva cross flag at the main in place of the narrow pennant.

2917. (1) No hospital ship, nor any of its boats or appurtenances, shall be used for any other purpose than such as may be necessary for the peaceful and humane service to which such ship is assigned.

(2) The neutrality of every hospital ship shall be strictly preserved at all times.

(3) No guns or ammunition, except such as may be necessary to maintain order on board and to defend the sick and wounded; and no other articles of the nature of contraband of war, except coal or stores necessary for the maintenance and movement of the ship, shall be placed on board; nor shall any hospital ship be used as a transport for the carrying of mails, dispatches, officers or men not sick, disabled, or shipwrecked, other than those regularly attached to such vessel.

2918. Hospital ships shall be subject to the provisions of article I 908 in regard to the inspection of hospitals by the commander-in-chief within whose jurisdiction they may lie.

2919. (1) The commanding officer of a hospital ship shall be governed by the Navy Regulations and Naval Instructions in all respects, so far as they may be applicable to him as the officer in command of a naval hospital and medical supply ship. Under these regulations he shall have full authority in all matters concerning the discipline and punishment of the medical and dental officers and members of the Hospital Corps, Nurse Corps (female), and Red Cross personnel on board, and of all officers and men on board under treatment, to the same extent as is the case in a naval hospital on shore.

(2) In the absence or during the disability of the officer in command, the command shall devolve upon the medical officer next in rank attached to the vessel not detailed by the Department for special duty, until relieved by proper authority.

(3) All orders for a hospital ship shall be given through the commanding officer, who shall have the general direction of the movements of the vessel, leaving the master, however, to exercise full and unquestioned control and authority over all matters within his technical purview, and for which he is professionally responsible. Any order from the commanding officer relating to other than the medical department of the ship shall be given to or through the master.

2920. Such additional medical officers as the Department may deem necessary shall be attached to a hospital ship. Their duties shall be as prescribed by the commanding officer, by the provisions of section 4 of this chapter and of sections 1 and 2, chapter 28, Naval Instructions, and by such other instructions as may be issued from time to time by competent authority.

2921. No person shall engage in the conveyance or transport aboard any hospital ship of any articles or packages other than those which are officially authorized, nor in any traffic, sale, or barter on board thereof.

2922. No intoxicating liquors of any kind shall be brought or used on board by any person, except upon the recommendation of the medical officers of the ship, approved by the commanding officer.

2923. The civilian officers and members of the crew of a hospital ship shall be classified as in the Naval Auxiliary Service. The complement of such a ship shall be as specified by the Navy Department (Bureau of Navigation).

2924. (1) The master of a hospital ship shall have full and paramount control of the navigation of the ship and shall be responsible for the discipline and efficiency of the civilian officers and crew. He shall maintain and enforce strict discipline at all times and shall require his own authority and that of the other officers to be thoroughly respected by all subordinates on board.

(2) The master shall make himself thoroughly familiar with the regulations of the service and of the orders issued from time to time and he shall be responsible for their strict observance.

(3) He shall satisfy himself that the ship is in all respects seaworthy and properly fitted out and shall take such steps as may be necessary at any time to put or keep her in an efficient condition.

(4) He shall strictly comply with such rules or laws as may be adopted for the prevention of collisions or other accidents, both on the high seas and in inland waters.

(5) He shall see that the lights required by law, at sea and in port, are kept in good order and burning brightly during the night and that there are at hand, convenient for use, means for relighting or replacing any such as may be extinguished or otherwise become inefficient.

(6) He shall personally attend to the stationing of the crew for emergency drills and for their proper exercise at such stations.

(7) When under way on soundings, or when nearing land, approaching an anchorage, or when necessary to verify the ship's position, he shall have casts of the lead taken frequently.

(8) He shall be held responsible for the safe conduct of the ship, notwithstanding the presence of a pilot, and also for accidents occurring while bringing the ship to piers or docks.

(9) He shall himself take the bridge in thick weather and when approaching or leaving land and shall keep it as much as possible while in channels or crowded waters, especially during the night.

(10) He shall enter regularly in the night order book the course to be steered and all necessary instructions to the officer on duty, and this book shall be initialed every night by the officers on watch.

(11) He shall take care that the boats of all kinds are constantly ready for service, with all gear in them properly fitted and ready for hoisting out; that the boats' falls are kept rove and the lowering apparatus ready for use.

(12) He shall see that the crew is properly organized for service in the boats and properly exercised in getting them out and handling them.

(13) He shall see that the crew is properly organized and stationed for fire service, and that it is properly drilled in the use of the fire appliances. Before sunset each day he shall ascertain that the fire apparatus and pumps are ready for immediate service, with hose coupled and buckets with lanyards at hand and kept filled.

(14) He shall see that collisions, groundings, and similar occurrences are entered in the ship's log, with full and exact particulars thereof.

(15) In the case of a collision or other occurrence of like nature, he shall at once prepare and forward a written report signed by him, through the commanding officer, to the Navy Department (Bureau of Navigation), detailing the circumstances in connection with the occurrence. If he is not on deck himself at the time of the casualty, he shall, for the purpose of making his report, obtain from witnesses written statements of all the facts.

(16) He shall certify to the correctness of the quarterly statement showing the total number of rations issued to the civilian crew.

2925. The first officer is the aid to the master, and, subject to his instructions, is particularly responsible for the good order and cleanliness of the ship, for the adequate and efficiency of the crew, and for the servicewhich consists of all navigation and deck appliances.

2926. (1) The chief engineer is responsible for the care and good management of all steam propelling, pumping, hydraulic, refrigerating, electrical, auxiliary, and other machinery on board, and for all air, water, and steam pipes for sanitary, ventilating, heating, cooking, and other purposes. He shall use all the resources of his department to keep the machinery in proper working order and shall make the required reports of its performance, condition, and necessary repairs to the master, who shall forward the same to the Navy Department. He shall supervise and keep himself fully acquainted with all repairs and alterations made in port.

(2) He shall be responsible to the master at all times for the general supervision and conduct of his department.

(3) He shall have control, under the master, over all persons in his department, and shall see that strict discipline and efficiency are maintained at all times.

The Army regulations provide as follows:

570. On over-sea expeditions *hospital ships* and *ships for patients* may both be required, and will be provided by the War Department.

(*a*) Hospital ships are Medical Department organizations, and will be used solely by that department. In addition to carrying ill and injured between ports they may be utilized for carrying Medical Department personnel and supplies when this does not interfere with their primary object. Every hospital ship (including every hospital ship furnished by the American Red Cross) will be commanded by a medical officer of the Army. Its personnel is fixed (see par. 588), but its matériel will be determined according to the special necessities of the case.

(*b*) Ships for patients are ordinary transports or vessels turned over to the Medical Department for temporary use in emergencies when the necessary hospital ships are not available. During such use they will be under the command of the senior medical officer on duty thereon. So far as practicable only the less severe cases will be carried on such ships. Insane patients and cases of contagious disease will be carried on them only under exceptional circumstances. Both the personnel and matériel of such ships will be determined by the Surgeon-General according to the special necessities of each case.

(*c*) The commanding officer of a hospital ship or ship for patients will render the required reports and returns, maintain proper discipline in his command, and be held responsible for any deficiency of supplies or equipment due to his failure to institute timely measures for the renewal or replenishment thereof.

(*d*) So far as possible the commanding officer of a hospital ship or a ship for patients will notify the receiving hospital, in advance, of the date she will arrive and the number of her patients, so that suitable preparation for receiving the patients may be made.

The Ideal Hospital Ship.—Heretofore hospital ships have been converted into such from ships of the merchant marine. Cattle ships and emigrant steamers are, however, not the best material for hospital purposes any more than a stable or a lodging house is adapted for this purpose ashore. In most instances it is the best thing available involving the least time and expense to alter. British, German, and American naval officers have recently written articles which have awakened interest in each of these countries.

Fleet Surgeon D. J. P. McNabb of the British Royal Navy considers the ideal hospital ship to be a vessel of 3,000 to 4,000 tons, with a speed of about twelve knots per hour, and accommodations for some 240 sick in peace and 340 in war.

The German view as expressed by Marine Oberstabsarzt Dr. zur Verth inclines to a vessel of 5,000 tons displacement, 124 meters long, 15.3 meters beam, and coal capacity of 900 tons; such a vessel designed to have a total capacity of 270 beds, twenty of these being for contagious cases. Dr. zur Verth is of the opinion that two ships of this size would find a greater usefulness than one ship of double the capacity.

In February, 1912, before a conference of medical officers of the Atlantic Fleet, Guantanamo Bay, Cuba, Surgeon E. M. Blackwell, U. S. Navy, read a paper on the hospital ship. He incorporated in his plans many new ideas, the result of experience with ships of this character. It is probable, however, that the first hospital ship for our Navy will be an oil burner, with a large steaming radius, and have accommodations for nearer 500 sick than 250.

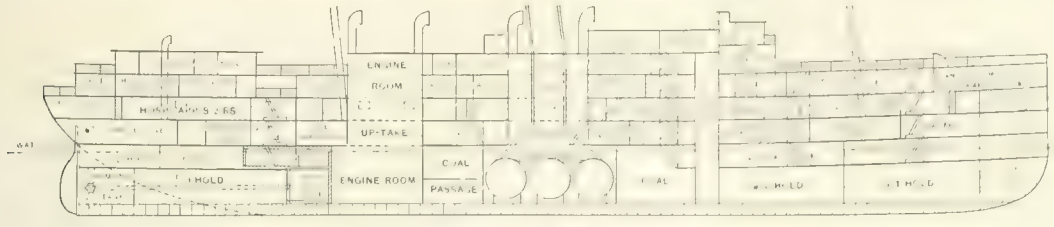
Surgeon Blackwell describes his proposed ship as follows: In June, 1911, the writer submitted to the Bureau of Medicine and Surgery plans and description of a hospital ship of about 10,000 tons, 500 beds and extra berthing space for about 300 more patients, making a total of 800 besides the crew. These plans were made with a view to having the Medical Department fully prepared in case of war. The Bureau did not consider that the present needs of the service required such a large vessel, and suggested that a ship of about 200 beds would be sufficient for some years to come, in time of peace. Besides, the expense of building so large a ship would be greater than it was thought advisable to ask for, and a smaller one was thought more advisable until the subject of hospital ships was more fully developed. Acting on these suggestions, the writer submitted plans in September, 1911, for a smaller ship of about 6,000 tons, 250 beds and extra berthing space for 150 more patients, making 400 besides the crew. It would not be advisable to have one of smaller size than this on account of the lack of space and stability that it would necessarily have. Stability in a ship is one of the greatest factors in the care, comfort, and treatment of patients on board, and every effort should be made to obtain it. These plans provide for a ship with very broad beam in proportion to her length, which will make her steady, comfortable, and roomy. She will be high out of the water, but all the heavy weights will be low, which will give her the required stability.

	Feet.
Length over all	352
Length water line	340
Breadth molded	56
Depth molded	40
Draft water line	22
Displacement	6,000
Complement:	
Naval	70
Auxiliary	115
Total	185
Beds for sick	250
Extra berthing space	150
Total	400
Triple expansion engines, indicated horsepower	6,000
Twin screws, diameter, feet	15
Speed, knots	12–16
Boilers, 6 Scotch:	Feet.
Length	12
Diameter	14
Coal capacity, 1,500 tons.	

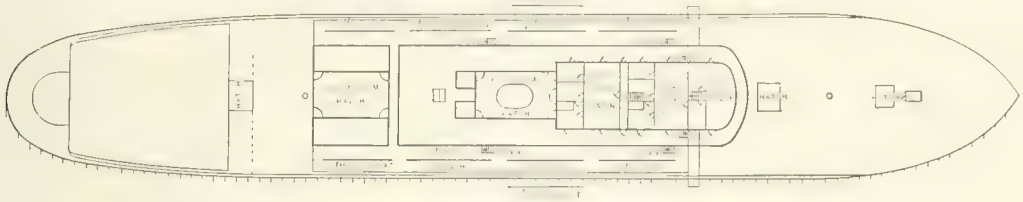
There are seven decks to this ship, including boat deck and hold, and a brief description of each is here given. (See Plate XXXVIII.)

The boat deck begins at frame 48 and runs aft to frame 123. On it is a deck house containing the pilot house, on top of which is the bridge; a chart room and navigator's storeroom; the master's quarters, and the commanding officer's quarters. The fresh-water gravity tanks are on this deck, aft of the smokestack. There is a wide gangway around the deck house extending aft to the end of the deck. There are ten large boats on this deck, with patent davits for hoisting and lowering, viz., two motor boats, two whaleboats, and six cutters. This deck is thirty-four feet above the water.

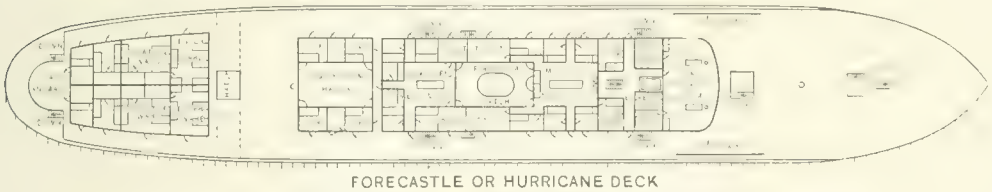
The forecastle and hurricane deck begins at the bow and extends aft to frame 170. It has a deck house beginning at frame 48 and ending at frame 123, in which are located the following compartments: The main operating room, with sterilizing, etherizing, and



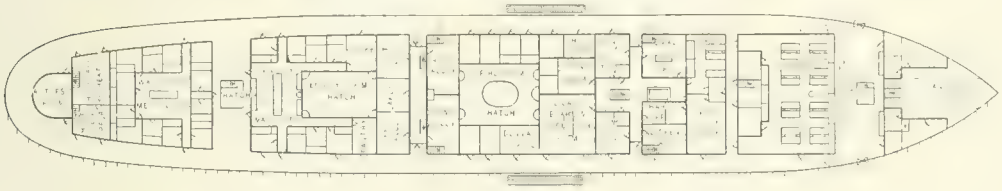
INBOARD PROFILE



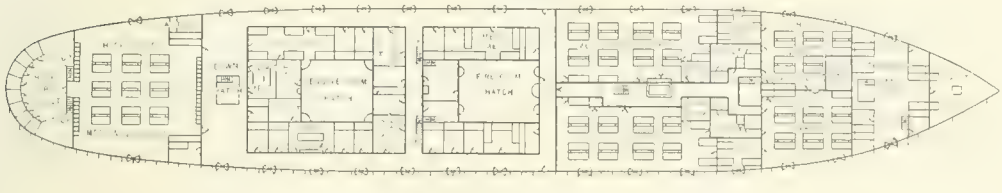
BOAT DECK



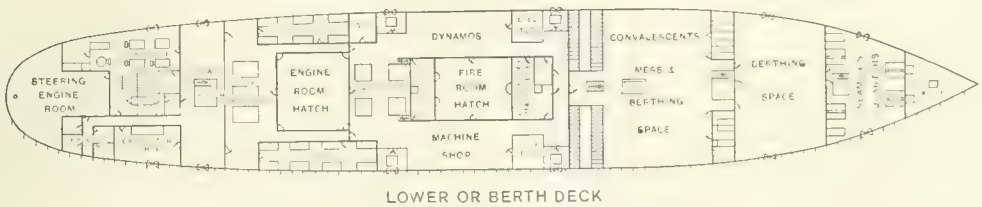
FORECASTLE OR HURRICANE DECK



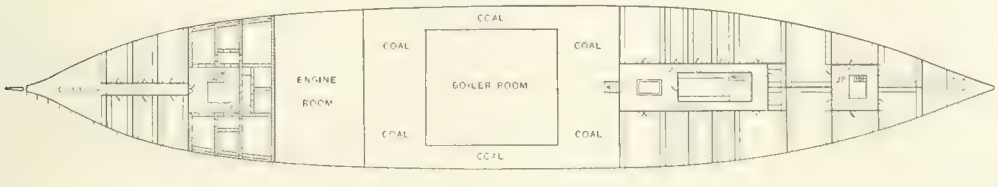
UPPER DECK



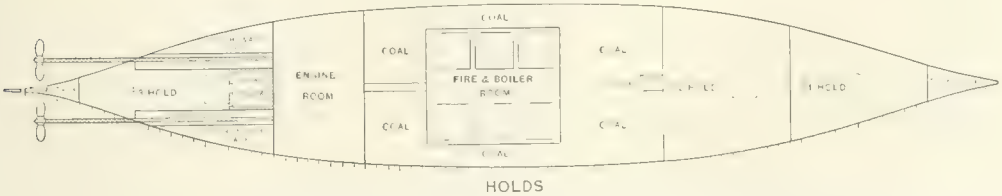
MAIN DECK



LOWER OR BERTH DECK



ORLOP OR STORE ROOM DECK



HOLDS

AN IDEAL HOSPITAL SHIP, DESIGNED BY SURGEON E. M. BLACKWELL, U. S. N.

wash-rooms attached; ward-room, with eight staterooms, pantry, and toilet for medical officers; sick officers' quarters, consisting of mess room and pantry, ten staterooms, and three toilets. On the after part of this deck, between frames 139 and 164, is a deck house containing the six isolation wards with a combined capacity of fifty-two beds, two rooms for nurses, and wash and sterilizing rooms. Each ward has its own toilet and is a separate unit in itself. Laboratory animals are kept aft of this deck house. The forecastle extends aft to the forward deck house and has two thirty-two-foot steamers on the after part of it. It affords ample space for exercise and recreation for convalescent patients. A companionway and two large hatches with ladders in them lead down to the compartments below, making communication ample and easy. The hurricane deck runs along the sides and around the after part of the deck house and affords an excellent place for exercise and recreation for the ship's officers and sick officers. Communication is had with the decks above and below by stairways and ladders, and there is an elevator that leads from this deck clear through to the hold. There is a wide gangway around the isolation wards, so that contagious cases can get out on deck and get fresh air and sunlight. This deck is twenty-six feet above the water.

The upper deck extends the whole length of the ship. Forward are the anchor engines, ship's petty officers' and seamen's toilets and wash rooms, aft of which comes the convalescents' recreation room, with barber shop and toilet attached. Just aft of this room the sides of the ship are cut away from the forecastle deck down to this deck, and a six-foot gangway runs down each side of the ship to and around the stern. From forward, aft, the following compartments are located on this deck, viz., a venereal ward of forty beds with dressing room and toilet; an eye examining room with dark room, toilet, and small ward of ten beds attached; dispensary; pharmacist's office and small operating room; offices for executive officer, officer of the day, and officer of the deck; bacteriological and chemical laboratories; *x*-ray and photographic rooms; library; board and reception room; dental, first officer, chief engineer, wireless, civil clerk, pay offices, wireless operators, and pay clerk's rooms. There are four galleys and a bakery, centrally located and very accessible to all parts of the ship, with dumb-waiter and ladders leading below, where overhead food carriers will distribute food to the main wards and messes of the ship. The auxiliary officers' quarters, consisting of mess room, pantry, and toilet, and eight staterooms, come aft of the galleys. Then comes a fourteen-foot athwartship passage with a large hatch in the center, aft of which come the sick quarters of the junior and warrant officers, consisting of mess room, pantry, toilet and nine staterooms. Aft of these are two recreation rooms for the hospital corps, aft of which is the autopsy room. This deck is eighteen feet above the water.

The main deck has storerooms forward, aft of which come the quarters of the ship's petty officers, aft of which, between frames 22 and 78, come the main wards of the ship. There are two medical and two surgical wards with dressing rooms and toilets attached, and also a hydrotherapeutic room. There are also two quiet rooms of three beds each. The total capacity of these wards is 136 beds. Just aft of the wards are two small diet kitchens where nurses can prepare special food and diets for patients at all hours. Between frames 78 and 140 around the fireroom and engineroom uptakes are grouped the quarters of some of the engineer officers, hospital stewards, commissary and mess stewards, mess cooks and boys, machinists and oilers, with mess rooms, mess issue rooms, sculleries, toilet, and wash rooms. On the after part of this deck are the canteen, post office, hospital, apprentices' quarters, and toilet. There are thirty large, square ports on this deck besides smaller ports, which give excellent light and ventilation to the wards and other living spaces. This deck is ten feet above the water.

The lower or berth deck has a storeroom and seamen's quarters forward, aft of which, between frames 26 and 71, come two large berthing spaces capable of accommodating about 150 convalescent patients when it is necessary to crowd the ship to its fullest capacity. Strong rooms for the insane and two bag and hammock rooms open into the after one of these compartments. Between frames 71 and 110 around the fireroom hatch are most of the auxiliary machinery, utensil sterilizers for the wards, engineer and electrical storerooms, machine shop, dynamo room, evaporators, and firemen's and coal passers' wash room and toilet. There are two large cargo ports on each side of this space, which open into handling rooms, with large coaling hatches in them. These handling rooms have water-tight doors in the inner bulkheads, so that coaling can be done entirely in these rooms and practically outside of the ship. Between frames 110 and 132 on either side of the engineroom uptake are the firemen's and coal passers' quarters, and the refrigerating machinery is aft of it. The laundry, dry room, clothes locker, and laundrymen's quarters are on the port side in the after part of this deck, and the carpenter shop and ship's prisons are on the starboard side. Between these are the main sterilizing and disinfecting rooms. The steering engine room is in the extreme after part of this deck. This deck is two feet above the water.

The orlop or storeroom deck has the ship's storerooms forward, aft of which are the medical storerooms. These are accessible through large cargo hatches, which have ladders leading up and down. The elevator and a stairway also run down to the medical storerooms and hold. The upper parts of the coal bunkers, boiler room, and engine room are amidships, between frames 65 and 126. Aft of frame 126 come the cold storage rooms, eight in all, and the commissary storerooms, seven in all. A large hatch with freight elevator and ladder runs down into this space, making the storerooms very accessible.

There are three holds, one forward for ship and equipment stores, aft of which is one for medical stores. Large cargo hatches lead down into these holds, and the elevator runs down to the one for medical stores. The coal bunkers, boiler room, and engine room occupy all the space between frames 58 and 126. The dead room comes aft of the engine room, and then comes the after hold for stowing coffins, lumber, and other heavy material. A large cargo hatch with freight elevator opens into this hold. There is a large fresh-water storage tank on the outboard side of each shaft alley.

Attention is called to the excellent means of communication between all parts of the ship. There are wide passages and gangways to facilitate communication between the various parts of the same deck and elevators, stairways, ladders, and hatches to facilitate communication between the different decks. None of the wards has to be used as a passageway or gangway to get from one part of the ship to another. A ward should never have to be used as a passageway or for any purpose other than caring for and treating the sick. The forward elevator and stairway adjacent to it extend from the boat deck down to the hold, passing from the commanding officer's quarters through the spaces occupied by the medical officers' quarters and operating rooms, the administrative, executive, and other offices, laboratories, dispensary, *x*-ray room, wards, berthing spaces, medical storerooms, and hold, giving excellent communication between all these compartments. The galleys are centrally located and are very convenient to all the principal messes. Movable cots should be installed, so that they could

be put out of the way, or wards could be cleared of all those that are not in use or filled up with them when there is a big influx of patients. Dr. Blackwell has designed a cot, several of which are in use on the U. S. S. *Solace*, which meets these conditions admirably.

Conditions can never be ideal on board a hospital or other ship on account of the lack of space and consequent crowding and congestion, and things have to be adapted to meet conditions and circumstances as they exist. Sometimes good ventilation and sanitation will have to be sacrificed on account of convenience and lack of space, and *vice versa*. It will require excellent judgment to determine just what features should be sacrificed for other features, in order that the ship as a whole may be best adapted to the uses for which it is intended.

RICHMOND C. HOLCOMB.

Hot Lake Mineral Spring.—Union County, Oregon.

POST-OFFICE.—Hot Lake. Sanatorium.

ACCESS.—Via the main line of the Oregon-Washington Railroad and Navigation Company. Hot Lake is 2,702 feet above sea-level, an elevation specially beneficial to those suffering from the various respiratory diseases so common in many localities. The summers are not extremely hot, and the winters are not uncomfortably cold. In the distance across the beautiful Grande Ronde Valley tower the snow-capped peaks of the Eagle range. Every afternoon an invigorating breeze redolent of pine and fir, comes down from the forests of the Blue Mountains. The Hot Lake Mineral Spring, 600 feet from the railroad, gushes from a rent in the earth's crust, a stream of boiling water, of crystal clearness, and soft and velvety to the touch. The flow has been estimated to be nearly 3,000,000 gallons every twenty-four hours. Not far from the spring is a semi-extinct geyser from which continually exudes a soft, fine, hot mud. This is the mud used in the mud baths. It is kept clean by the water from the spring which pours over it forming the hot lake. In other words, the mud geyser is the bottom of the lake. The mud, fresh for each individual, is carried to the bath-house, and is then carted away. The supply of this medicated mud is unlimited.

The water from the great spring contains in perfect solution various minerals and gases of medicinal value. The internal use of the water causes profuse perspiration.

The Hot Lake mineral bath is distinctive. It has been found to be specially beneficial to those suffering from diseases of the kidneys, stomach, skin, and blood, as well as the various forms of rheumatism and gout.

The mud bath is far reaching in its effects, and is very valuable in relieving congestion and inflammatory troubles of the lower limbs and pelvic organs.

"In the vapor bath, the vapor from the natural hot water is used. This bath gives great relief in cases of bronchitis, and catarrhal affection and hypostatic congestion of the lungs, jaundice, and chronic biliousness."

The salt glow is also given in connection with the medicated baths. The mineral water appears to be highly radioactive, due doubtless to the passage of the tremendous volume of minerally charged hot water over extensive beds of pitchblende. Such deposits exist very near to the spring.

At Hot Lake Sanatorium, besides the affections already mentioned, the liquor and drug habits are treated. These patients are completely segregated.

The equipment of the Hot Lake Sanatorium is modern in all respects. The building is solidly constructed of brick, stone, and wood. It is three stories high, and more than two city blocks in length. The hospital department is scientifically complete, both in surgical and laboratory equipment. The medical staff is most efficient. The baths and sanatorium are connected. The non-mineral water used is brought from a pure mountain spring well up in the timber belt. There is a modern cafetaria; also a fine grill. The mammoth building is heated throughout with hot water from the mineral spring. Indoor and outdoor sports offer varied recreations to the guests. At this resort one can enjoy a restful vacation, and have at the same time the advantage of the baths and mineral water.

EMMA E. WALKER.

Hot Springs, Arkansas.—

POST-OFFICE.—Hot Springs, Garland County. Hotels: Arlington, Eastman, Pullman, Park, Majestic, Josephine, and many others. Boarding houses.

ACCESS.—Via the Iron Mountain Route and Little Rock and Hot Springs Western Railroad. Over these lines run through sleepers from Chicago (via Chicago and Alton Railroad), a solid through train from St. Louis, through sleepers from Memphis and Kansas City, and through service from Texas and Louisiana points. The springs are about sixty miles southwest of Little Rock, the State capital. The Hot Springs are situated on the Mountain Creek and in the valley of the same name. They issue from the western slope of the Hot Springs Mountain, a spur of the Ozarks, at an elevation of 1,000 feet above the Gulf of Mexico. The mountains on either side attain an altitude of several hundred feet higher. The climate in this region, as a general rule, is mild and balmy and not subject to extremes of either heat or cold. Sunstroke is unknown, and the summer nights are generally cool and pleasant, light blankets, as a rule, being required before morning. The pure mountain air and constant southerly breezes unite in forming a healthful and invigorating climate.

These springs have been known and utilized as a health resort since early in the last century, and during that time they have acquired an extended reputation in the treatment of certain diseases. A city, Hot Springs, with numerous excellent hotels, sanatoriums, bathing-houses, and public buildings has been developed about them. Some of the handsomer and more commodius bath-houses were erected at a cost of from $15,000 to $75,000. Among the more prominent of these are the Eastman, Arlington, Park, Alhambra, Superior, Palace, Magnesia, Ozark, Horseshoe, Rammelsberg, Imperial, Moody, Lamar, and Maurice pavilions. The discharge of water from the springs amounts to 1,000,000 gallons per day; and the average temperature of the waters is 135° F. These waters are nearly all concentrated in large, air-tight tanks, built by the United States Government. The United States Government made an analysis of the forty-four hot springs in the year 1903. They are all very similar, and below is given that of the Big Iron Spring, the largest of the group.

The following statements are given as the opinion of twenty physicians of long experience in the use of the waters: "On account of their natural heat, their absolute purity, and consequent unparalleled solvent and eliminative action, together with the presence of a combination of hydrogen and silicon, and of free carbonic acid gas in large quantities, the former acting as a powerful tonic and stimulant, and the latter rendering them so palatable and exhilarating that they can be drunk *ad libitum*, at a temperature at which all known waters, either naturally or artificially heated, would be nauseating, all soluble medicines can be administered and tolerated while using these hot waters in much larger doses than elsewhere; hence they are more active and produce beneficial results in less time and with greater permanency."

Persons taking the baths here should always do so under the supervision of one of the local physicians. Those affected with organic disease of the heart or recognizable physical signs of consumption are not allowed to bathe, as the thermal action of the water is liable to be prejudicial to such cases. If the lungs

are but slightly involved, careful bathing may be permitted. Furthermore, cases of simple cardiac palpitation are not excluded. As each case must be treated on its merits, and as detailed instructions are given by the local physician, it is unnecessary here to enter into a minute description of the bathing process at Hot Springs.

	Parts per million.	Per cent. of total inorganic material in solution.	Amount of water used for each determination.
			c c
Silica	45.59	16.00	10,000
Sulphuric acid radicle	7.84	2.75	4,000
Bicarbonic acid radicle	168.10	59.02	100
Nitric acid radicle	0.44	0.16	100
Nitrous acid radicle	0.0016		100
Phosphoric acid radicle	0.05	0.02	8,000
Arsenic acid radicle	None		5,000
Metaboric acid radicle	1.29	0.45	6,750
Chlorine	2.53	0.89	700
Bromine	Trace		8,000
Iodine	Trace		8,000
Fluorine	None		15,000
Iron and Aluminum	0.19	0.07	8,000
Manganese	0.34	0.12	4,000
Barium	Trace		15,000
Strontium	Trace		6,000
Calcium	46.93	16.48	4,000
Magnesium	5.10	1.79	4,000
Potassium	1.60	0.56	4,000
Sodium	4.76	1.67	4,000
Lithium	Trace		4,000
Total	284.7616	99.98	
Total Solids	198.50		200
Albuminoid Ammonia	0.035		500
Oxygen required	0.55		200

Temperature, 147° F.; daily flow, 201,600 gallons. Gases (number of cubic centimeters per liter at 0° C. and 760 mm. pressure)—nitrogen, 8.80; oxygen, 3.79; carbon dioxide (free), 6.92, in combination, 30.02; hydrogen sulphide, none.

In regard to ailments benefited and cured by the aid of the hot waters, the following is taken from a circular written by a Surgeon-General of the United States Army: "Relief may be reasonably expected at the Hot Springs in the following conditions: In the various forms of gout and rheumatism, after the acute or inflammatory stage; neuralgia, especially when depending upon gout, rheumatism, metallic or malarial poisoning, paralysis not of organic origin; the earlier stages of locomotor ataxia; chronic Bright's disease (the early stages only), and other diseases of the urinary organs; functional diseases of the liver; gastric dyspepsia, not of organic origin; chronic diarrhea; catarrhal affections of the digestive and respiratory tracts; chronic skin diseases, especially the squamous varieties, and chronic conditions due to malarial infection."

The city of Hot Springs itself is well drained and well lighted, and has ample police and fire protection. It now claims a permanent population of 20,000. About 150,000 persons visit the place annually, and this number is ever on the increase. The United States Government Army and Navy Hospital erected here receives retired and active soldiers and sailors of the army and navy. The government has spent more than a million dollars on this hospital and the grounds surrounding it. Among other mineral springs within the limits of the city of Hot Springs, or in the neighborhood, are the following: Allen's Alterative Spring, situated on Central Avenue, in the heart of the city; Gillen's White Sulphur Springs, located three miles from Hot Springs; Mountain Valley Springs, situated twelve miles north of Hot Springs at the foot of Blakely Mountain, in a beautiful valley extending well up into the mountain range; and Potash Sulphur Springs, located seven miles east of Hot Springs on the Hot Springs Railroad, one mile from Lawrence station. The ownership and control of the Hot Springs of Arkansas by the United States Government is absolute. Congress, after due investigation took possession of the springs in 1832, and retained around them a reservation ample to protect them from all encroachments. It was the first national park reservation of the country. By this act they are set apart as "A National Sanitarium for all time," and "dedicated to the people of the United States to be forever free from sale or alienation." In the year 1904 the State Legislature passed an act granting the general government exclusive jurisdiction and sovereignty over the reservation. Since then the government has made rules and restrictions for those who dispense the waters and practice in connection with them, the results of which are of great benefit to the sick.

Comfortable accommodations may be secured at moderate rates. The price of baths and attendants' fees are fixed by the government. Among the numerous improvements made by the government is the system of driveways and walks on the three mountains comprising the reservation. There are about fifteen miles of drives and six miles of walks.

Amusements are varied.

The hotels and bath houses are open throughout the year. EMMA E. WALKER.

Hot Springs, North Carolina.—

POST-OFFICE.—Hot Springs, Madison County. Mountain Park Hotel and boarding-houses.

ACCESS.—From the north and east by through Pullman cars on the Pennsylvania and Southern Railroads; from the west and northwest via Louisville, or via Cincinnati by the Queen and Crescent route. The location is thirty-five miles west of Asheville. The picturesque little village of Hot Springs is situated on the western boundary of North Carolina, only three miles from the Tennessee line, in the heart of Big Smoky and Blue Ridge Mountains, on the banks of the beautiful French Broad River. The location is 1,700 or 1,800 feet above the sea level. The atmosphere is dry and invigorating and the climate mild and equable, there being a very large proportion of clear days. The hotel, thoroughly modern, is surrounded by a beautiful private park of 100 acres on the banks of the French Broad, while through the grounds runs "Spring Creek." There is a fine golf course. The springs have long been popular in the South, but in recent years they have come into high favor with Northern visitors also. They are about twenty in number, and the temperature of the waters ranges from 96° to 110° F. They form one of the only two groups of hot springs east of the Mississippi from Canada to the Gulf of Mexico. The following analysis was made by Professors Chandler and Pellew, of New York:

ONE UNITED STATES GALLON CONTAINS: Solids.	Grains.
Sodium chloride	1.08
Potassium chloride	0.62
Potassium sulphate	1.62
Calcium sulphate	20.04
Magnesium sulphate	7.20
Ammonium bicarbonate	Traces.
Calcium bicarbonate	9.02
Iron bicarbonate	0.10
Sodium phosphate	Traces.
Alumina	0.04
Silica	3.14
Organic and volatile matter	Traces.
Total	42.86

The waters are quite similar to those of the Arkansas Hot Springs. Several of the springs have been encompassed in the limits of a fine, large bath-house, which

is divided into sixteen separate pools, nine feet long by six feet wide and three to six feet in depth. The water pours into these pools directly from the springs. The visitor will find here all of the modern appliances and improvements which go to make up a first-class bathing establishment of the day. These waters have been found to be very useful in rheumatism, gout, and in all troubles due to the so-called uric acid diathesis; in neurasthenia, indigestion of various forms, catarrhal affections, diseases of women, and disorders of the kidneys, bladder, and liver. Guests are received at all times of the year. With its lovely mountain scenery, its exhilarating climate, its thermal waters, and many other natural attractions, combined with a hospital and scientific management, this resort is well deserving of the wide reputation which it has obtained. EMMA E. WALKER.

Hot Springs, South Dakota.—

POST-OFFICE. Hot Springs, Fall River County. Numerous hotels and cottages. Boarding houses.

ACCESS.—Via the Chicago and Northwestern, or the Chicago, Burlington and Quincy Railroad direct to Hot Springs, arriving at the same depot by either route. This magnificent new spa is located in the heart of the Black Hills at an elevation of 3,400 feet above the sea level. The advantages of Hot Springs as a health resort are numerous. First as to the topographical features. The scenery in and adjacent to the place is varied and delightful. The lofty pine-clad hills, grand canyons, rippling streams, and beautiful falls of the Minnekahta and Cheyenne, make up a group of attractions difficult to excel.

Second as to climate. By reason of certain peculiar circumstances of location this resort is favored by very mild, equable atmospheric conditions. Summer days are followed by evenings of delicious coolness, while the autumns are unusually pleasant. Situated in the Minnekahta valley and sheltered on all sides by heavily timbered hills, cold winds and sudden changes of temperature are practically unknown. The winter temperature in the valley is from 20° to 25° higher than in localities only a dozen miles distant. It is said that the protection afforded by the hills is supplemented in no small degree by the millions of gallons of hot water flowing through the valley. The sun shines 332 days each year. Dust and winds are almost unknown here.

The accommodations are excellent. The largest hotel, is the Evans. Other excellent hotels are the Gillespie, the Hot Springs, the Braun, the Iowa, the Minnekahta, the Siloam, the Fall River House, the Nicholson Apartment, the Valley House, and the Huebner. Cottages are also on hand for those who desire them. The hills afford attractive spots for camping out.

Adjoining the Evans House is the Evans Sanitarium containing sixty bath-rooms and embracing all varieties of baths. Among the most valuable institutions at Hot Springs are sanitariums and hospitals at which modern and scientific methods are employed.

This resort is noted for its magnificent plunge baths, receiving warm water direct from the springs in such immense quantities that the volume is changed every ten minutes. Besides the plunges there are excellent bath-houses. The water is at a natural temperature of 96° F. the year round. The springs at this resort are eight in number. The "Minnekahta" is the name given to a great Indian spring, the word being a synonym for health, pleasure, and recreation. It is said that the waters of this spring were in use by the Sioux and other tribes long before the approach of civilization. The natural temperature of this spring is 98° F. It furnishes the drinking fountain of the Evans House, the Evans bath-house, and the Minnekahta bath-house. An analysis by Prof. Charles B. Gibson, of Chicago, resulted as follows:

ONE UNITED STATES GALLON CONTAINS

Solids.	Grains.
Magnesium sulphate	4.32
Sodium sulphate	25.62
Potassium sulphate	
Iron peroxide	Trace.
Sodium chloride	13.57
Potassium chloride	
Calcium sulphate	16.32
Silica	2.64
Total	62.51

These waters are perfectly transparent, have a pronounced alkaline reaction, and contain no organic matter. Following are analyses of two of the other springs:

ONE UNITED STATES GALLON CONTAINS

Solids.	Mammoth Mineral Spring. Grains.	Lakotah Spring. Grains.
Sodium sulphate	23.26	8.82
Potassium sulphate	5.63	3.33
Calcium sulphate	36.11	16.29
Calcium chloride	5.59	8.50
Ammonium chloride	0.02	0.05
Magnesium chloride	4.11	3.14
Calcium phosphate		0.31
Magnesium nitrate	0.30	0.15
Magnesium phosphate	0.10	
Magnesium carbonate	3.51	3.04
Iron sesquioxide	0.15	0.26
Alumina	0.27	0.02
Silica	1.55	1.83
Organic and volatile matter	12.11	8.05
Total	92.71	53.79

These waters are of the sulphated-saline and calcic variety. According to a report of the National Association of Railway Surgeons, that visited the resort several years since, "treatment by the Hot Springs water may be said to stimulate all the secretions and organic functions; to promote digestion and assimilation, and to favor tissue metamorphosis and excretion, thereby relieving internal congestions, stimulating blood-making, increasing the appetite, and favoring new and healthy tissues at the expense of the old and inactive." This treatment may, therefore, be recommended in "gout and rheumatism after the inflammatory stage; in neuralgia, especially when depending upon gout; in metallic or malarial poisoning, paralysis not of organic origin, and neurasthenia; in the early stages of Bright's disease; in syphilis and functional diseases of the liver and stomach; in catarrhal affections of the respiratory tract, . . . and in chronic skin diseases especially of the squamous variety."

The United States Government has chosen Hot Springs as the site of a National Sanitarium for disabled soldiers. The "Battle Mountain Sanitarium" comprising a group of beautiful buildings was erected at a cost of nearly $1,000,000 and was opened in 1907. The South Dakota State Soldiers' Home is also located here.

Hot Springs is the county seat of Fall River County, and is located about seventy miles south of Deadwood. The town has a permanent population of about 3,500. Its proximity to extensive pine forests, in addition to the favorable features of location above mentioned, assists in preserving a mild and agreeable climate, and has brought the resort into much favor with persons afflicted with hay fever, asthma, and incipient phthisis. EMMA E. WALKER.

Hot Springs, Utah.—Salt Lake County, Utah.

POST-OFFICE.—Salt Lake City. Hotels.

These springs are located at the northern city limits

and can be reached by street car. Although there are nearby accommodations, most visitors make their headquarters at various hotels in Salt Lake City.

The following extracts are taken from a report of the committee, to Salt Lake County Medical Society, on the climatic conditions of Salt Lake City, Utah.

Utah is richly supplied with mineral and thermal springs which compare favorably with the waters of such celebrated spas as Baden Baden, Wiesbaden, Carlsbad, and other famous resorts of Europe.

An analysis of the water from the hot springs three miles north of Salt Lake City, from which the Salt Lake Sanitarium Company derives its water supply, shows the following medicinal ingredients:

One United States Gallon Contains: Solids.	Grains
Sodium chloride	248.375
Potassium chloride	2.125
Calcium chloride	10.432
Magnesium chloride	26.020
Calcium sulphate	36.070
Potassium sulphate	750
Magnesium, sulphate	16.875
Sodium sulphate	12.040
Sodium carbonate	7.875
Iron carbonate	925
Calcium carbonate	5.875
Potassium carbonate	1.020
Magnesium carbonate	25
Silicon oxides	2.070
Aluminum oxide	975
	371.452

Numerous tests reveal the presence of iodine, bromine, and fluorine in appreciable quantities.

Specific gravity	1.011
Chemical reaction	Alkaline
Gases	3.250 volumes.
Hydrogen sulphide	1.875
Carbonic acid	1.375

The thermal springs in the vicinity of Salt Lake City are rich in mineral ingredients. The climate is delightful. Within twelve miles of the city is Great Salt Lake, a celebrated bathing resort, the waters of which are very invigorating. Emma E. Walker.

Hot Springs, Virginia.—This resort is in Bath County on the Chesapeake and Ohio Railroad, 250 miles southwest of Washington and near the West Virginia border. The elevation is 2,400 feet with the Blue Ridge mountains rising on either side of the valley to a height of 3,700 feet above sea level. In the same valley are Warm Springs, five miles distant, and Healing Springs, three miles. These three localities have been famous for about 150 years for their thermal springs which range in temperature from 98° to 106° F. The Boiler Spring at Hot Springs has not varied from 106° F. since the observations published over 100 years ago. For internal use at Hot Springs there are the Magnesia Spring and Sulphur Springs. They are all antacid, diuretic waters and aid in the treatment of rheumatism, gout, oxaluria, catarrh of the bladder, arthritis, and other affections of that class. The plan of treatment usually adopted consists of baths in the water as it is delivered in the tubs at the natural temperature or a little below 100° to 104° F. The patient may or may not be rubbed by the bather in the flowing water. Several hundred gallons are required for each bath as it flows freely over the sides of the tub while the patient lies there. After the tub bath he is quickly dried in hot sheets, laid on a couch and enveloped in blankets and while in the hot dry blanket pack perspiration is favored. Following this he rises and is washed off with cooler water and is dried again and rubbed down thoroughly with alcohol. After three or four baths he rests a day without a bath and then begins a series of baths in which the first measure is the use of a fixed spout or jet of water having a temperature of 104° F. and a pressure of twelve to sixteen pounds to the square inch during five to eight minutes, and as he stands under it the jet is allowed to reach the trunk and limbs. This may be reduced in pressure for sensitive patients or omitted entirely but it acts as a decided stimulant and is of value in dispelling exudates and promoting the elimination, through the circulation, of morbid products. The use of a fixed jet of warm mineral water at an unvarying natural temperature and with its natural gases is not found elsewhere as far as we know.

The Boiler Spring is the main spring from which the water used in the bath-house flows. Its temperature in the spring is 106 degrees. Its analysis shows 43.25 grains of mineral salts per gallon. The constituents and proportions of these salts are:

Calcium	22.428
Magnesium	5.402
Sodium	2.759
Potassium	1.366
Alumina	Trace
Sulphuric acid	22.875
Chlorine	0.593
Carbonic acid	37.000
Water of combination	3.246
Silica	4.500
Combination of Acids and Gases.	
Magnesium sulphate	8.476
Magnesium carbonate	3.018
Calcium sulphate	1.895
Calcium carbonate	23.076
Sodium sulphate	3.664
Potassium sulphate	0.667
Potassium chloride	0.539
Silica	1.946

The carbonates of calcium and magnesium are held in solution as bicarbonates by the excess of carbonic acid.

The *Healing Springs* water is the principal water used internally at Hot Springs. Analysis shows the following mineral properties, temperature 84° F.

Magnesium carbonate	3.13867
Calcium carbonate	20.70289
Strontium carbonate	0.09331
Barium carbonate	0.00699
Iron (ferrous) carbonate	0.03033
Manganous carbonate	0.01225
Zinc, lead, copper	Trace
Magnesium sulphate	5.73208
Potassium	1.82069
Sodium	2.95556
Sodium chloride	0.68232
Sodium bromide	0.00408
Sodium iodide	0.00017
Carbon dioxide gas, free	10.56 cu. in.
Sodium phosphate	0.00933
Lithium chloride	0.05190
Rubidium	Trace
Calcium fluoride	Trace
Alumina	0.04316
Silica	1.36697

An analysis, chemical and bacteriological, shows that the water is free from organic matter and from bacteria.

Fifteen springs at Hot Springs, Warm Springs, and Healing Springs were tested for radioactivity in July, 1913, by Profs. Ernest Zueblin and J. C. Hemmeter of the University of Maryland. The results are given in Mache units.

Octagon Spring	25
Soda Spring	64
Healing Springs	86
Swimming Pool	109
Warm Springs	134
Hot Sulphur Spring	157
Boiler Spring	241
Magnesia Spring	285

These results place Healing Springs water in radioactivity between Kreutznach and Baden Baden;

Warm Springs, higher than Baden Baden; the Hot Sulphur Spring, higher than Gastein; and the Boiler Spring and Magnesia Spring, higher than Landeck and Gastein. These estimates were made directly at each spring and include the values for water and for contained gas.

In 1913 the mean average temperature at Hot Springs was 53° F.; the maximum 91° and minimum 3°. The rainfall was 44.68 inches. The Virginia Hot Springs Company operates hotels at Hot Springs, Warm Springs, and Healing Springs. The largest of these, The Homestead at Hot Springs, has a capacity of 800 and is open all the year. Treatment is uninterrupted at all seasons as the baths are directly connected with the hotel. The equipment includes douche tables, electric cabinets, and a complete set of Zander apparatus. The golf links comprise eighteen holes and there are attractive mountain walks and picturesque drives. One of the mountain walks has a uniform ten per cent. grade and is marked every tenth of a mile with distance and elevation so that graded exercises are possible. GUY HINSDALE.

Hot Sulphur Springs.—Middle Park, Grand County, Colorado.

POST-OFFICE.—Hot Sulphur Springs. Hotels.

ACCESS.—Via the Denver, Northwestern and Pacific Railroad.

These springs are located in the Middle Park on the banks of the Grand River, 7,625 feet above the sea level. This river forms the only drainage outlet to the Middle Park, a mountain basin ninety by fifty miles in extent. The inclosing peaks vary in height from 9,000 to 14,000 feet.

AVERAGE OF FIVE ANALYSES OF WATERS FROM DIFFERENT SPRINGS AT HOT SULPHUR SPRINGS, COLORADO.

Name	Hypothetical combinations	Parts per million
Silica	Lithium chloride	Trace
Sulphate	Potassium chloride	121.07
Bicarbonate	Sodium chloride	147.31
Carbonate	Sodium sulphate	188.46
Phosphate		
Hydrogen sulphide		
Chloride		
Iron	Ferrous bicarbonate	18.72
Aluminum	Calcium bicarbonate	66.92
Manganese		
Calcium	Silica	31.68
Magnesium	Manganese oxide	2.59
Potassium	Magnesium bicarbonate	7.44
Sodium	Sodium bicarbonate	1012.01

The prevailing weather in this section is clear, with westerly winds. There is considerable snow in winter, with a steady range of temperature of about 32° to 50° F., but occasionally dropping to 20° or 25° below zero. As many as twenty-two of the springs are well situated for improvement, but, according to the latest reports we have had, the baths now in use take water from only three or four. The exact flow of water cannot be stated, but it is believed to be greater than that of the Arkansas Hot Springs. A strong smell of sulphureted hydrogen pervades the neighborhood of the springs, and with a favoring wind may be noticed for a considerable distance up the valley. The channels through which the waters flow are lined with a soft yellowish-white, velvety substance having the odor of sulphur (probably a confervoid growth known as sulfuraria). This substance is evidently not a sediment, as it stands up like the pile of velvet or plush, and is not deposited in layers, while the water itself is as clear and bright as that of any mountain spring. It is said to be very palatable and to rest well on delicate stomachs. The following analysis is an average of five analyses of the waters at Hot Sulphur Springs made recently by the Colorado Geological Survey. The average is fairly representative of the whole group, the waters being very similar.

The waters are recommended in cutaneous, hepatic, uterine, neuralgic, gouty, and rheumatic disorders, and for the manifestations of tertiary syphilis. As with thermal waters generally, they are contraindicated in most acute diseases, in tuberculosis and cancer, in fatty degeneration of any important structure, in aneurysm or organic heart disease, and in predispositions to cerebral, gastric, pulmonary, or intestinal hemorrhage. There are several hotels at the Hot Sulphur Springs and several private houses where guests may obtain accommodations. EMMA E. WALKER.

House-fly.—*Musca domestica* is the common house-fly. It carries typhoid, cholera, dysentery. Other flies often found in houses are: *Drosophila* and many other infectious diseases, *ampelophila*, the fruit-fly; *Fannia canicularis* and *F. brevis*, the little house-flies; *Stomoxys calcitrans*, the stable-fly; *Rhora femorata; Sarcophaga trivialis*, the flesh-fly; *S. stercocaria*, the dung fly; *Calliphora erythriocephala*, the blow-fly; and *Anthomyia radicum*, the root-fly. See *Insects, parasitic.*

A. S. P.

House Sanitation.—The primary object of habitations is to secure protection from the influence of heat and cold, rain, sunshine, and storms, and thus promote the health and happiness, and indirectly also, the morals and culture of the human race. The influence of sanitary houses cannot be overestimated. Dr. Villermé, in an investigation in France from 1821 to 1827, found that of the inhabitants of arrondissements containing 7 per cent. of badly constructed dwellings, 1 person out of every 72 died; of inhabitants of arrondissements containing 22 per cent. of badly constructed dwellings 1 out of 65 died; while of the inhabitants of arrondissements containing 38 per cent. of badly constructed dwellings 1 out of every 45 died. The history of improved dwellings for wage-earners shows everywhere a lessened death rate.

1. *Site.*—One of the first requirements of a sanitary home is a salubrious building site with a thorough exposure to air and sunlight; the top of a small elevation is always to be preferred, because of better natural drainage, purer air, freedom from dampness, and greater safety from inundations. Hippocrates and Vitruvius have referred in their writings to elevation as a desirable factor. The tops of the highest hills are usually too much exposed to the wind, and when chosen in certain climates the house should be protected by trees on the windward side; next to the top of a hill, the slopes should be preferred with a southern, southeastern, or southwestern exposure, on account of the advantages of sunlight and greater cheerfulness. Sites located in depressions which receive the natural drainage from surrounding slopes should be avoided, as they are not only damp, but likely to be surrounded with cold air and chilling mists. It is scarcely necessary to insist that so-called "made soil" and close proximity to marshes and injurious industrial establishments should be avoided.

Next to the topography of the site the character of the soil is important in its influence upon the healthfulness of the home. In a general way a gravelly, sandy, or chalky soil of good depth on a slope makes the best building site, provided soil pollution has not taken place and the deposit is not upheld by some impermeable stratum of clay or rock near the surface. Clay, marl, peat, and made soils should be avoided, because they are damp and the presence of organic matter, apart from favoring the proliferation of disease germs, also tends to pollute the ground air which

is in constant communication and interchangeable with the atmosphere. See article on *Air* in vol. i.

While rock affords easy facility for surface drainage, Mr. T. M. Clark (Reference Handbook, first edition, Vol. III., p. 23) regards it as very objectionable, as the ledges are full of seams through which water usually flows, and the trenching necessary for the interception of the springs formed in this way is so costly that it is usually neglected, and cellars built on rock are in consequence generally damp.

The temperature of the upper layers of soil, and hence also its dryness, depend largely upon its exposure to the sun; but it is well known that heat is variably absorbed and retained in different soils equally shielded or unshielded by vegetation. The following table by Schubler shows the capacity of different soils of absorbing and retaining heat—100 being assumed as the standard:

Land with some lime	100.0	Clayey earth	68.4
Pure sand	95.6	Pure clay	66.7
Light clay	76.9	Fine chalk	61.8
Gypsum	72.2	Humus	49.0
Heavy clay	71.1		

It will be seen, therefore, that sandy soils are warmer and clayey soils are not only damp but also very much colder.

Unfortunately, "ideal building sites" are within the reach only of comparatively few, and steps must therefore be taken to render objectionable sites as sanitary as possible; for the purpose of securing dryness, attention must be paid to the prompt removal of surface water and of subsoil water, the site should be drained by means of suitable drains four to six feet below the floor of the cellar or basement; indeed this precaution should not be neglected even in comparatively dry soils in order to limit the fluctuations of the ground water. In the preparation of the building site it is always desirable to excavate sufficiently deep to get rid of surface pollution, and it is perhaps needless to insist that in grading no soil containing the rubbish and wastes of human life and occupation should be used. In isolated buildings the surface drainage should be directed away from the house and the environments improved, with due regard to light and air, by either favoring the growth of vegetation or by removal and pruning of excess and overproduction.

2. *Building Material.*—The most common materials used in the construction of buildings are wood, brick, sandstone, limestone, granite, marble, iron, steel, and other metals, glass, terra-cotta, cement, mortar, asphaltum, and concrete. Of these materials, iron, zinc, copper, cement, slate, vitrified brick, glazed terra-cotta, and granite are quite impermeable, while others are not, depending upon the degree of their porosity and hygroscopic properties—according to Lang –

	Per cent. of water by volume.	Or, per cent by weight
Soft-burned bricks absorb	32.70	19.13
Hard-burned bricks absorb	28.20	16.50
Mortar burned bricks absorb	26.00	14.80
Portland cement absorbs	17.80	11.00
Limestone absorbs	17.70	7.26
Dolomite absorbs	14.70	6.50
Sandstone absorbs	10.80	4.34
Porphyry absorbs	2.75	1.05
Slate absorbs	0.93	0.35
Granite absorbs	0.61	0.23
Marble absorbs	0.59	0.32
Serpentine rock absorbs	0.56	0.22
Vitrified bricks absorb	0.00	0.00

A wall built of ordinary brick and mortar is capable of absorbing large quantities of water. Pettenkofer has calculated that 10,000 gallons are incorporated in a house built of 100,000 ordinary sized bricks. Bricks burned from clay containing much saltpeter and sulphate of sodium are especially objectionable, as a deposit is formed on the outside of the walls and moisture is attracted.

Galton, in his work on healthy dwellings, has shown that marble and limestone conduct more heat than an equal thickness of glass, bricks, plastering, and wainscoting. This appears to prove what experience has practically demonstrated, that frame and brick buildings are more readily warmed than marble and limestone structures of equal size and thickness of walls.

The hygienic importance of the properties of the building material cannot be underrated. Its porosity largely determines the interchange of air through the walls and the temperature of the rooms, thus greatly influencing ventilation and heating. The pores, as in the soil, contain either air or moisture; if air, the heat is conducted slowly, while water conducts heat readily. The hygroscopic properties of the material influence capillary attraction and diffusion of moisture, and consequently also the permeability and heat-conducting powers of the walls. Walls saturated with moisture absorb much heat and render transpiration of air impossible. It is for this reason that a house with damp walls appears much cooler to the inmates in summer than a dry one; but damp walls are decidedly objectionable, because they not only render the air of the room damp and impure and abstract more heat from the inmates, but also favor the growth of microorganisms.

It will be readily understood that the application of paint, wall paper, and even calcimining will affect, if not completely check, the transpiration of air through the walls. For hot climates, frame and other forms of wooden buildings possess the advantage that they cool off very rapidly after the sun has disappeared, but because of their inflammability, short duration of life, and other sanitary disadvantages, such buildings cannot be recommended. But, as long as they are being extensively used in this country, special precaution should be taken in planning such buildings to prevent the entrance of cold winds at the junction of the wood walls and the stone underpinning. For this purpose Mr. Clark recommends a few courses of brick in mortar to be laid upon the cellar wall just behind the wooden sill; and as regards the exclusion of cold air through cracks or crevices in the cornice, he suggests the construction of a four-inch wall of brick and mortar on top of the plate which forms the top of the wall and supports the floor of the rafters, carrying it up until it meets the roof boarding. This wall, besides its use in keeping out cold winds, is also of some value in checking the spread of fire. Frame houses can be rendered cooler in summer and warmer in winter by double plastering inside and by covering the outside walls first with rough boards and a layer of Cabot's quilt and an exterior finish of clapboards or shingles.

Cement stucco on wood or preferably on metal laths makes an excellent exterior finish for a frame house. It may be colored any agreeable shade and should be water-proofed with some of the approved compounds added while the mortar is being mixed. This finish has the advantage of being non-combustible, quite durable, and is not dependent upon paint.

In spite of certain objections to brick, they are on the whole the most desirable material for ordinary dwellings; they resist fire better than any other material, and a hardstock pressed brick of a light color is quite impermeable to moisture and makes a pleasing and hygienic outer wall. Next to brick, granite, marble, lime, and sandstone are most frequently used, especially in connection with iron and steel in the construction of fireproof buildings. None of these rocks can resist the ravages of fire as well as brick.

Silicious sandstone stands the action of fire better than granite, marble, or limestone, as these rocks when subjected to high temperatures and a stream of cold water will chip and crack.

Terra-cotta is now very extensively used not only for floor and partition construction but also for exterior facings. For the latter purpose glazed or semi-glazed terra-cotta in any desired color and design, plain or ornamental, may be chosen. The material is practically impervious to moisture and is also a good non-conductor of heat. The hollow terra-cotta blocks used for interior partitions have recently been successfully employed in the construction of suburban houses as a substitute for brick interior and exterior walls. Such exterior walls are stuccoed in the manner already referred to and offer many hygienic advantages over ordinary frame or brick construction in the matter of safety, dryness and heat conduction. Concrete construction for the entire house has proven very successful and is not only fire, rat, and vermin-proof, but also practically indestructible.

Microorganisms in building material are especially numerous in the filler for ceiling spaces, which is frequently selected without regard to its source, old plaster and other rubbish being used; Emmerich has isolated the pneumococcus in such material, and Bonome found the bacillus of tetanus in mortar.

The latter being a mixture of sand and lime, the inference is that it was derived from sand, and that the spores were not destroyed by the action of the lime. Wall papers, unless very smooth, harbor a large number of microorganisms; we also know the danger of house fungi, especially the *Merulius lacrymans*, in bringing about the "dry rot" in pine lumber, as well as the frequent occurrence of moulds in dark and damp places.

Construction of the House.—Dryness of the foundation and walls, as already indicated, must be secured by draining the subsoil four to six feet below the cellar or basement and covering the entire floor with a layer of cement concrete six inches thick, rammed solid, and this should be coated with one inch of cement. In this way not only dampness, but the equally obnoxious ground air are excluded. To prevent the dampness of the soil from rising in the walls by capillary attraction, the foundations must be laid in concrete and hydraulic cement and a horizontal course of slate bedded in cement should be interposed between the concrete footings and wall, and another course of slate just as the foundation walls reach the ground level. Since these slate courses are liable to fracture, the last damp-proof course should consist of vitrified hollow brick, which, moreover, possess the advantage of securing ventilation. Some architects recommend damp-proof courses of tarred-felt asphalt or sheet lead (Fig. 3249).

The exterior walls of a house, whenever practicable should be separated from the ground by an "open area," extending from the foundation upward; but where this cannot be done, a "dry area" may be formed by constructing a hollow wall to the ground level, provided with the usual damp-proof courses, and if springy, also with a subsoil drain at the bottom, at the same time protecting the wall in contact with the ground with a coat of slate embedded in cement. Mr. Clark suggests that if the ground is springy, a strip of tarred roofing felt, a little wider than the wall, should be laid upon the footings just below the cellar floor, and the stonework continued upon it. This, he says, "will prevent moisture from rising in the walls by capillary attraction from below, and with the coal-tar coat on the outside, a cellar with walls of porous material may be made dry and wholesome at small expense." The practice has become quite common now of simply pargeting the outside of the walls below grade with cement and sand mixed in the proportion of 1:2, to which should be added one of the approved water-proofing compounds either in powder form or as a paste dissolved in the water with which the mortar is made. It is also advisable to mix water-proofing compounds with floor and footing concrete.

In localities with considerable rainfall it will be well to protect the side or rear walls of a rough brick building from driving rains with either a coat of cement, mineral paint, tar, or glazed tiles. Such a precaution is unnecessary when hard-pressed bricks are used. In recent years the application of a coat of water-proof paint under the plaster on the inside of the exposed wall has replaced most of the other methods. Reference has already been made to the fact that during the construction of a building an immense amount of water is incorporated with the bricks, mortar, and plaster. This water should be gotten rid of before the house is occupied, by thorough airing and drying, but not too rapidly, as a rapid evaporation prevents the carbonate of lime from becoming crystallized and the mortar loses its binding qualities. If the house has not been properly dried, the walls are very likely to sweat, which is in part due to their own moisture and partly to the condensation of the respiratory vapors on the damp cold walls. Laveran states that a building is not fit for occupancy as long as the wall plaster contains more than twenty-two per cent. of moisture (see Examination, p. 352).

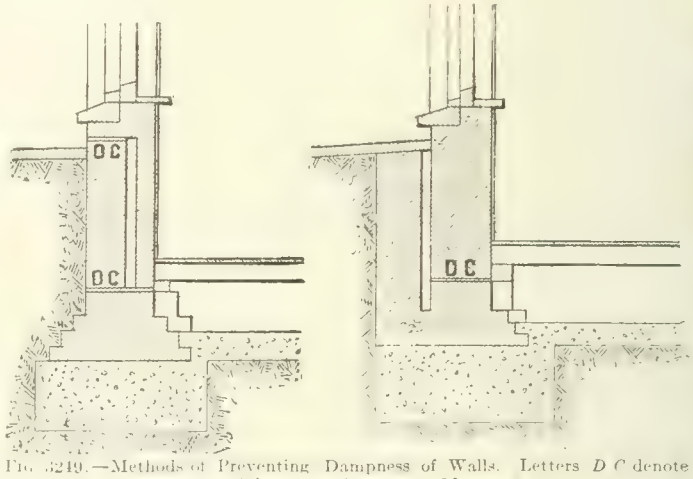


FIG. 3249.—Methods of Preventing Dampness of Walls. Letters *D C* denote location of damp-proof course. (Munson.)

Roof and Roofing.—A good dry roof is another important factor, because water often gets to the walls through a defective roof and the whole house becomes damp. Metallic roofs with a sufficient pitch are most commonly used and usually secure this needed protection; but as they heat very rapidly a tin roof should be painted white and a good non-conductor should intervene. For this purpose a double course of boards with a layer of Cabot's quilt, corked or Florian building-paper may be used. The tin, of course, is properly secured to the upper sheathing with a layer of felt paper directly beneath the tin. In any event there should be also an air space of two to three feet between the upper ceiling and the roof, and this space should be ventilated with perforated bricks in the walls and circular ventilators at the highest points of the roof. It is also a good plan, in order to prevent rusting, to cover the tin with a coat of mineral paint on the under side. All tin roofs should have flat soldered seams for a distance of five or six feet back from the gutter, so that, if the gutter is stopped up the water cannot back up under the seams. Slate, cement, slag, and

tiled roofs, when properly constructed, afford protection against dampness, fire, and heat. In rural districts wooden shingles are still extensively used, and such roofs when treated with creosote and covered with rubber or metallic paint last for about twenty years. Whatever kind of a roof is used, free access to it should be provided by means of stairs or a ladder through a suitable opening, which in summer can be utilized for the escape of hot air. Special attention should be paid to the gutters and rain leaders; the openings of the latter should be protected with a network of galvanized iron, so as to prevent dead leaves, scraps of paper, mortar, birds' nests, etc., from passing through and clogging the conductors. The gutters should be periodically cleaned to prevent accumulation of rubbish and the overflow resulting therefrom. Subsequent leaks and defects should be promptly repaired. A leaky rain spout may keep the entire house damp. Copper or galvanized iron should be chosen instead of tin for gutters and conductors.

Floors.—Hygiene demands that the floors should be impervious to dirt, moisture, and germs, and should therefore be well seasoned, tongued, and grooved, and closely matched; veranda or exposed floors should be laid in white lead. All crevices resulting from subsequent shrinkage should be neatly filled with strips of wood, putty, paint, or wax. There should be a subfloor of rough pine with a double layer of Florian building paper between; the top floor should not be laid until after the building is trimmed out, it should then be planed off and treated with a mixture prepared as follows: Dissolve by heat one pint of paraffin pared into shavings in two pints of raw linseed oil. To this solution add two pints of liquid dryer and sufficient turpentine to thin it to the desired consistency. This will give a gloss finish. If a dead finish be desired, about one-half of the quantity of paraffin should be used; apply with brush the same as varnish. If a high degree of polish be desired, rub with a polishing brush. One gallon of this mixture will cover approximately two hundred square feet of floor surface. Floors may also be first treated with a coat of shellac and then waxed. Waxed floors unless highly polished are, however, far from sanitary, since the dust and germs become imbedded in the wax, for similar reasons carpets are objectionable; "lignum salvor" a creosote oil preparation for both floor and woodwork finish has been highly recommended. While none of the various floor varnishes in the market are wholly satisfactory, they still constitute the most sanitary floor finish.

Oak and other hard-wood parquetry floors are not only attractive but also offer every hygienic advantage. In warm climates cement or "granito" floors may be advantageously used. The latter are really nothing more than cement concrete floor, four to six inches in thickness, with chips of marble and granite of various colors embedded in the upper layer and polished. They are practically insect and vermin proof, especially desirable for kitchens, pantries, and bathrooms, and should supersede the use of linoleum and rubber floor coverings. In order to prevent cracks in "granito," expanded metal or other reinforcement should be imbedded in the concrete base. Composition floors such as compressed cork or "karbolith," etc., have come into use; the latter are jointless, easy to walk on, and can be applied over old floors, and when used for hospitals or bathrooms can have a cove base run on continuously with the floor.

Ceiling Space.—As a filler for the ceiling space, with a view of deadening sounds and as a protection in case of fire, special hollow bricks, dry cinders, clean dry mortar and peat, impregnated with milk of lime, have been used. Metallic laths are preferable to wood.

Stairs.—The stairway should be so constructed as to afford an easy ascent with risers not exceeding seven inches in height and treads from ten to twelve inches in width. For public buildings and tenement houses iron stairs and fire-escapes are demanded; indeed, even private houses would be better off with these safeguards in case of fire.

Halls.—The halls of a house should be roomy, well-lighted by direct light, if possible, and susceptible of ventilation. In a modern private dwelling the hall on the first floor is five or more feet in width and leads into the reception room, from which proceeds an open stairway to the upper floors. The open stairway should be lighted and ventilated by means of a skylight.

Interior Arrangements.—In regard to the size of the dwellings it is always best if they are simply large enough to accommodate one family. Overcrowding should be avoided, as infectious diseases are more liable to spread in consequence of aerial infection and the more intimate contact of the occupants. Körösi, of Budapest, has shown that out of every one hundred deaths from contagious diseases, there were:

20 deaths in dwellings with 1 to 2 persons in each room.
29 deaths in dwellings with 3 to 5 persons in each room.
32 deaths in dwellings with 6 to 10 persons in each room.
79 deaths in dwellings with over 10 persons in each room.

The following table, prepared by Rohé, shows the relation of death rate to density of population:

City.	Mean number of inhabitants to each house.	Average annual death rate per 1,000 inhabitants.
London	8	24
Berlin	32	25
Paris	35	28
St Petersburg	52	41
Vienna	55	47

It would be unfair, however, to attribute this increased death rate solely to overcrowding; other factors must be considered, since, as well expressed by Ogle, "The more crowded a community the greater, generally speaking, is the amount of abject want, of filth, of crime, of drunkenness, and of other excesses." Nevertheless, these mortality statistics demonstrate the baneful effects of tenement houses. With the present rapid-transit facilities in every city, our voice should be clearly in favor of individual homes; and when this is impracticable, we should insist on broad streets and deep yards. No more than sixty-six per cent. of the lot should be covered by the house, and the height of the building should never exceed the width of the street.

No field affords better opportunity for philanthropic work than the removal of slums and erection of sanitary houses for wage-earners at reasonable rentals. Acting upon this, the Washington Sanitary Improvement Company was organized in 1897, and Surgeon-General Sternberg and the writer prepared plans in which no detail was omitted which would tend to provide the best accommodations from the standpoint of hygiene. Each house has a frontage of seventeen and one-half feet and consists of two independent flats, one on each floor, the special feature being that each flat constitutes a complete home, having a separate entrance and exit, separate yard and cellar. The entrance to the flat on the first floor opens into the front or sitting-room, thirteen feet two inches by fourteen feet; back of this room is a hallway leading to the bedrooms, ten by thirteen feet two inches; bathroom five feet one inch by six feet eleven inches, and kitchen twelve by twelve feet. The entrance to the flat in the second story is by a staircase with access through a doorway on a level with the one opening into the flat on the first floor, but at the other end of the front of the house. Each flat has three large closets, and the kitchens are provided with a

range, hot-water boiler, dressers, and sinks. Every room receives direct light and air, and the plumbing is the best. These flats rent for $12 per month, with a rebate of one month's rent every year to tenants whose apartments have not required repairs. The company has paid five-per-cent. dividends from the beginning and accumulated a surplus fund at the rate of two per cent. per annum. No officer receives any compensation, and this promotes the philanthropic aspect of the enterprise by providing the very best accommodation from the standpoint of hygiene, and as to comfort the utmost which a given cost will provide. The company was awarded a gold medal at the Paris Exposition in 1900, the only company in the United States to receive that award.

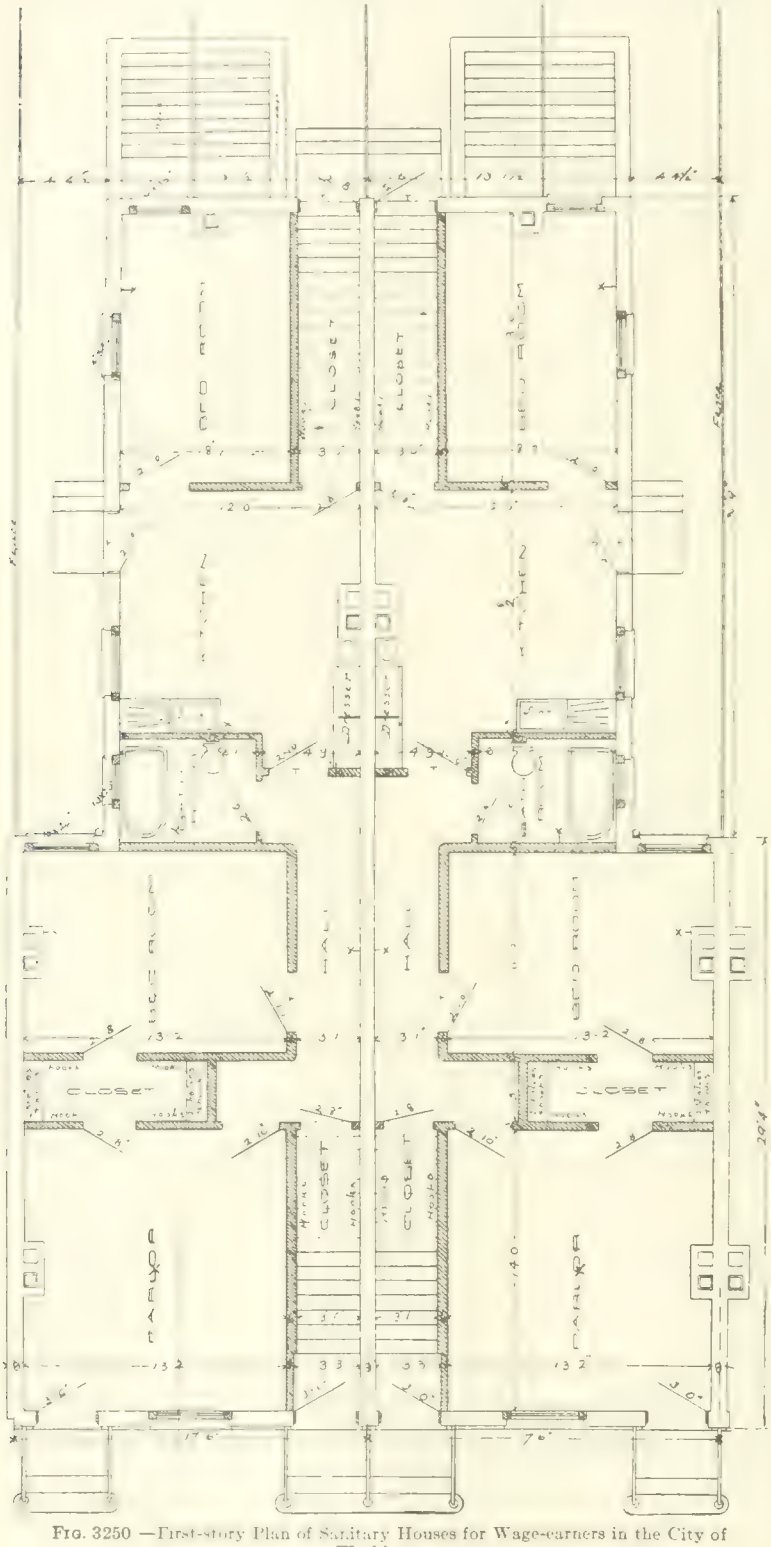


FIG. 3250.—First-story Plan of Sanitary Houses for Wage-earners in the City of Washington.

Basements are always desirable, even in small houses, for storerooms, heating plants, and kitchens; they should be at least eight feet from floor to ceiling, not over one-half below ground, well lighted, and with all precautions taken to prevent the odors of the kitchen from passing into the upper stories. This can be done by a closed stairway and a deep hood over the range, which should conduct the gases into a flue located next to the smoke-flue. In the more commodious houses the first floor usually consists of three large rooms, parlor, reception, and dining-room, to which, in double houses, a library may be added. When practicable, the kitchen should be located in a one-story wing with pantry intervening between the kitchen and dining-room. This isolates the kitchen and odors from the main house, and is preferable in many respects.

The rooms of the first floor, or parlor floor, should be from ten and one-half to eleven feet high and liberally supplied with windows, while the upper stories may be ten and nine and one-half feet in height. Living and sleeping apartments for obvious reasons should not be tolerated in basements. The largest and sunniest apartment in the house should be chosen for the nursery and living room. The bedrooms should also be bright and sunny, and rooms with northern exposure avoided as much as possible for regular bedrooms. In this connection the stimulating effects of sunlight upon tissue metamorphosis and its destructive influence on microorganisms should be remembered. No room should have a borrowed light, and this can be avoided by the construction of ample air and light wells in city houses which are three or four rooms deep. The windows should be made to open at top and bottom. Sleeping porches are being rapidly introduced and are generally attached to the upper stories of the rear of the house adjoining the bedrooms; some architects have secured good results in corner houses by supplying one or more rooms with an abundance of French windows opening into loggia.

Interior Finish and Decorations.—Hygiene cannot approve of decorations or an interior finish which

serve as dust and germ traps. In all houses dust is produced by the wear and tear of domestic activities and our object should be to prevent its accumulation and facilitate its removal. Cornices and projections on ceilings and walls, the mouldings of door and window frames, wardrobes, carpet, and cumbersome draperies all tend to collect dust and microorganisms; they are not tolerated in hospitals and should be abolished in sanitary houses.

When the floors are neatly polished, it is quite sufficient to have a few small rugs which can be easily taken up and shaken and the floors cleaned with a damp duster. Heavy curtains and draperies should give way to light, airy fabrics, which can be easily washed. The bedroom furniture should be light, simple, and limited to the most necessary articles. Every bedroom should be provided with a commodious closet, supplied with clothes shelves, hooks, and drawers, and if the mirror is sunk in the panel of of the door, wardrobes and dressing-cases could be conveniently dispensed with. All corners and angles of the inside of the house should be rounded to facilitate the removal of dust.

Wall Decorations.—The wall coverings should be as smooth as possible, since rough and highly-embossed paper and hangings accumulate an enormous quantity of dust and germs. On the whole, the plain kalsomined or painted walls outrank from a sanitary point of view the gorgeous decorations of the palatial homes. Flat washable paints can now be had in all tones and are largely replacing paper and kalsomine. Green paint and green-colored wall papers should be rejected; indeed, since arsenic has been found in various colored papers other than green, no paper should be used unless guaranteed to be free from arsenic, as much harm may be done by arseniureted hydrogen, which tends to produce a chronic form of arsenical poisoning, characterized by conjunctivitis, cough, nausea, and diarrhea, with colic, cramps, and debility.

The air of habitations differs from the exterior air in this, that unless precautions have been taken, it may contain the elements of ground and sewer air; but even in the best-appointed houses the air is vitiated by the products of respiration, combustion, and decomposition of organic matter. As a matter of fact we always find an excess of carbon dioxide as much as 5.88 volumes per 10,000 having been determined in basements, 4.59 on the first floor, 4.50 on the second floor, and 4.19 on the third floor. We also find an excess of organic matter, most probably derived from the lungs, mouth, and skin of the occupants. Some authors deny that the skin and lungs in perfect health give off anything impure, but experience points to the fact that even the cleanest and healthiest persons exhale an organic substance which clings to bedding, clothing, carpets, and walls, and imparts that peculiar close and offensive odor to bedrooms and other inhabited apartments. Indeed, Uffelmann never failed to find ammonia nitrates in the air of his rooms, amounting to from 0.108 to 0.072 mgm. as compared with 0.025 mgm. per cubic meter in the outer air.

We also find more dust and germs than in the open air. If on a windstill day we expose two glass slides moistened with glycerin, one in the outer air and the

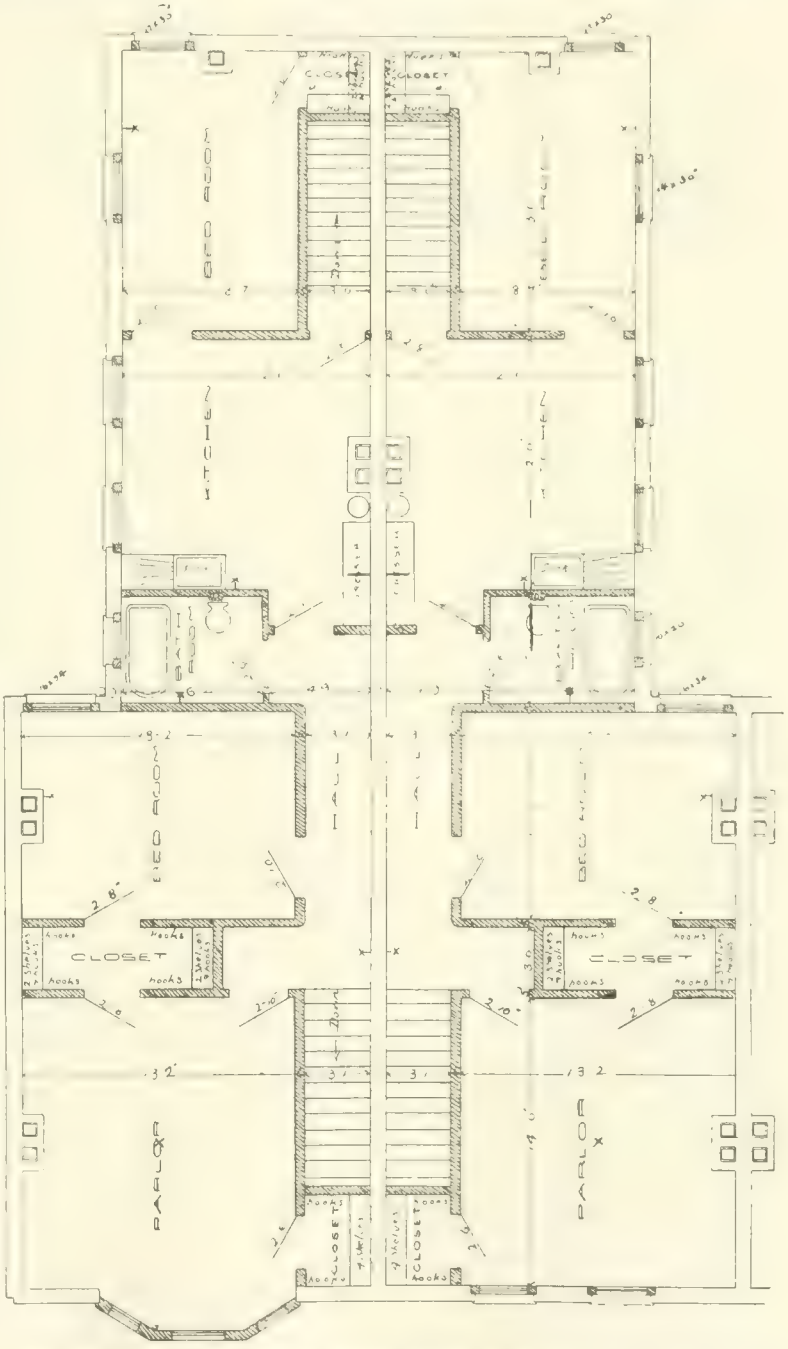


Fig. 3251.—Second-story Plan of Sanitary Houses for Wage-earners in the City of Washington.

other indoors, we shall find at the expiration of twelve hours that the slide exposed indoors will contain a larger amount of dust, and that the organic constituents which in the outer air amount to about thirty per cent. are present to the extent of about fifty-seven per cent. It has also been shown that when the exterior air contained only 6.5 mgm. of dust per cubic meter, the air of even well-ventilated houses contains an average of 16.8 mgm. per cubic meter.

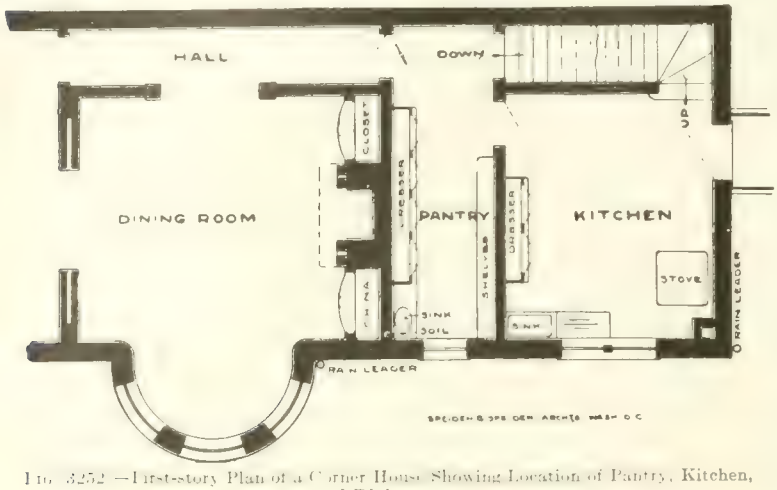


FIG. 3252.—First-story Plan of a Corner House Showing Location of Pantry, Kitchen, and Dining-room.

The number of microorganisms in the air of even the better class of houses is invariably greater than in the open air, and depends largely upon whether the dust has been stirred up or not. Thus Uffelmann found the outer air thirty-nine inches above ground to contain 250 germs per cubic meter; one of his rooms during a perfect calm to contain 7,500 per cubic meter, and one, after shutting two of the doors vehemently, 27,000 per cubic meter.

Cellar air contains usually more organic matter and CO_2, and the degree of humidity amounts often to complete saturation, but the number of germs is less than in other parts of the house.

The *relative humidity* of the air of habitations when not heated is usually quite constant. It is, of course, influenced by the exterior air, but the fluctuations are never so marked as outdoors. This is probably due to the fact that the walls and furniture absorb moisture and give it off to less hygroscopic substances.

The *temperature* of habitations, with the exception of the upper floor, is also very much more constant than that of the open air. The maximum temperature in summer usually occurs five hours later than in the open air; for this reason our houses are hotter about six o'clock in the evening than at twelve or one o'clock. The thickness and construction of the walls determine this to a great extent. Houses constructed with walls having a four-inch air space are cooler in summer and warmer in winter.

Ventilation.—When we consider that an adult individual exhales on an average 14.4 cubic feet of CO_2 during twenty-four hours, and recall the other polluting factors, such as the products of combustion and decomposition, and that the presence of individuals tends to vitiate the air with dust, germs, and organic matter from the skin, mouth, and lungs, while the watery vapor eliminated by the lungs and skin, amounting to about 550 grains per hour, is sufficient to saturate ninety cubic feet of air at a temperature of 60° F., we see at once the necessity for the renewal of air in our habitations. Since it would be neither prudent nor expedient to wait until the air becomes literally unfit to breathe, it is self-evident that the dilution of impure and diffusion of pure air should be constant and gradual. The next question arises. How much fresh air is required to renovate the vitiated air? It has been found by careful observation and experiments that no appreciable organic odors are perceived in the air of inhabited rooms until the volume of CO_2 exceeds six volumes per 10,000. "When the carbonic acid amounts to seven volumes, a want of freshness is observed on entering. When nine, ten or more volumes are present, the organic odor becomes manifest" (Smart). We know, of course, that this volume, or even double the quantity, of carbon-dioxide is not in itself harmful, but as it goes hand-in-hand with an increase of organic matter, it is an index of the amount of organic impurities, and its estimation, according to Smart, affords the best means of testing the efficiency of the ventilation. Our object should be, therefore, to supply a sufficient amount of pure air so that the volume of CO_2 may not exceed six volumes per 10,000. From careful calculations (see Dr. Smart's excellent treatise on *Air*, p. 163, vol. i.) it has been found that in order to accomplish this result, an average adult requires about 3,000 cubic feet of fresh air per hour. It is evident that the supply of fresh air can be introduced only by a movement of the air, which is brought about either by a diffusion of the gases or by the difference in weight of masses of air of unequal temperature and the pressure resulting therefrom. It is well known that gases have the prop-

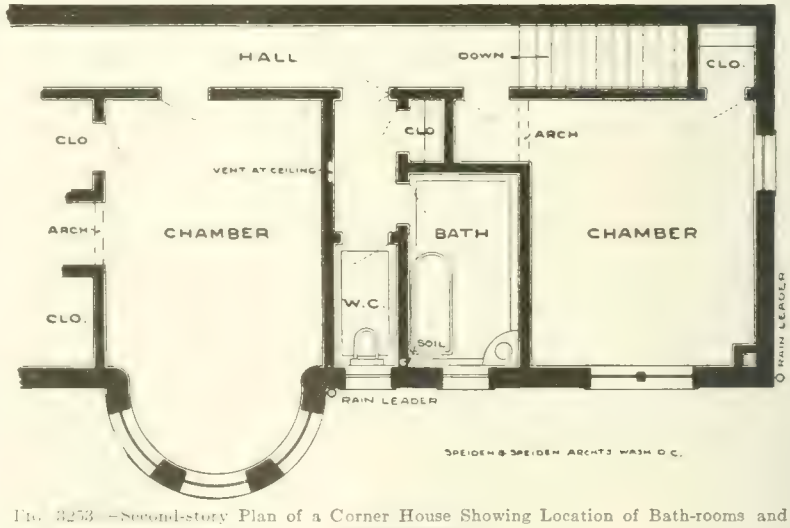


FIG. 3253.—Second-story Plan of a Corner House Showing Location of Bath-rooms and Water-closets.

erty of penetrating or spreading and mingling with others in every direction, and this diffusion takes place through all porous substances, even a dry brick or stone wall. If it were not for this power of diffusion, CO_2, by reason of its specific gravity, would sink to the lower part of the room.

An unequal temperature produces a difference in weight of masses of air. When air is heated it expands; a volume of hot air is consequently lighter than the same volume of cold air. The warm air rises, and to restore the equilibrium the cold air rushes in to occupy its place. This is exactly what takes place in nature. The sun supplies the heat, and the currents of air, or winds, are thus produced, which in turn serve as powerful ventilating agents in our habitations. The winds act chiefly by perflation, *i.e.* by setting masses of air in motion, driving them onward by an irresistible *vis à tergo;* they also exert an aspirating effect, for when passing horizontally over chimneys or tubes placed at right angles to their course they cause a diminution of pressure within them, the air being practically sucked out, other air from below rushes up to fill the vacuum, and thus an upward current is produced. We see, therefore, how ventilation, which means the removal and dispersion of bad air and the introduction of fresh air, may be brought about by all these factors which operate to a greater or less degree in what is commonly called *natural ventilation,* and which is usually sufficient when each occupant has 1,000 feet of cubic air space and the walls of the house are porous or contain numerous crevices near the doors and windows, and the difference between the inner and outer door temperature is considerable and the winds strike the walls directly or pass with great velocity over chimney flues and other openings. Professor Pettenkofer has shown that by these natural means his library, having a capacity of seventy-five cubic meters, received hourly at a difference of temperature of 20° ninety-two cubic meters of fresh air, of 19° seventy-five cubic meters of fresh air, and of 4° twenty-two cubic meters of fresh air. But as we cannot control the direction and force of the winds, and the other factors referred to, we should provide additional means for ventilation, and one of the simplest and most efficient plans is to flush the room with fresh air by opening windows or doors on opposite sides of the room. No other method can take the place of this periodical airing for a thorough ventilation of the dead corners and the removal of an immense amount of dust. The objection to this method is the cold draughts in winter, and it should therefore be relied upon chiefly in summer or during the absence of the occupants. In rooms heated with direct radiation, the fresh air should be admitted above the heads of the occupants, either by means of a register in the wall or by the insertion of a louver or swinging window pane (Fig. 3255) in one of the windows, an upward direction being given to the air so that it may impinge on the ceiling, mix with and be warmed by the heated air in this situation, fall gently into all parts of the room, and be gradually removed by means of the chimney flue or any other outlet. Another simple plan is to bore standing holes in the bottom rail of the window sash, or to insert a "Pullman ventilator" in the bottom rail of the lower sash, or to employ the "Bury ventilator," which consists of a wooden block interposed between the bottom of the lower sash and the frame. The air passes into the room through the openings in the block which, as in the "Pullman ventilator," point upward. The separation of the sashes caused by the block also adds to the fresh-air inlet. The use of these devices practically invades the domain of and brings us to the consideration of

Artificial Ventilation, which may be secured by providing, 1. Suitable inlets and outlets; 2. By extraction by heat, or the creation of a decided difference between the inner and outer temperature; and 3. By propulsion and aspiration.

1. *Special Inlets and Outlets.*—For the admission of air, perforated bricks are sometimes built into walls and concealed behind the washboard. When unwarmed air is to be admitted, the *Sheringham valve* is very commonly used. In this apparatus (Fig. 3256) the air passes through the walls by means of a perforated iron plate and is then directed upward by a valved plate with side checks. This plate being hinged is capable of being more or less completely closed by a balanced weight; it usually measures three by nine inches. *Watson's tube* has two chambers placed alongside of each other, one serving as an inlet and the other as an outlet (Fig. 3257). *McKinnell's ventilator* consists of two cylinders, one inside the other, and of different lengths; the longer tube projects above and below and serves to conduct the impure air, while the outer cylinder having a larger sectional area serves as the inlet. The outlet is protected on the top with a cowl; both tubes can be regulated by valves. They are especially useful for the ventilation of one-story buildings, churches, theaters, kitchens, and pavilion hospitals. The gas burner may be placed immediately under the extracting tube; as the warm air escapes through the inner tube, a corresponding volume is admitted through the interspace between the two cylinders (Fig. 3258).

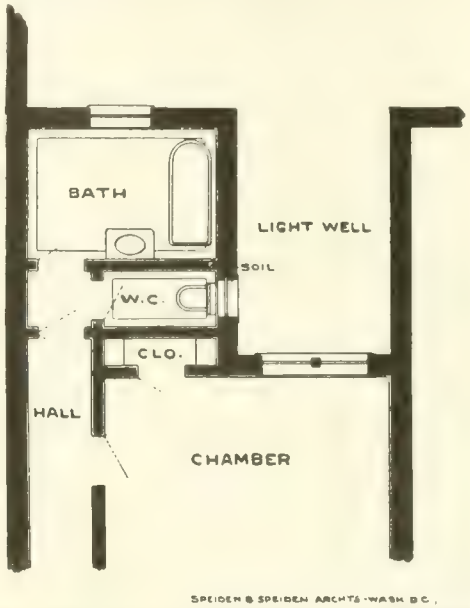


Fig. 3254.—Second-floor Plan Showing Location of Bath-rooms, Water-closets, and Chambers on an Inside Lot.

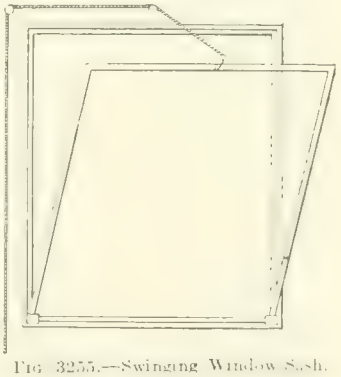


Fig. 3255.—Swinging Window Sash. (Munson.)

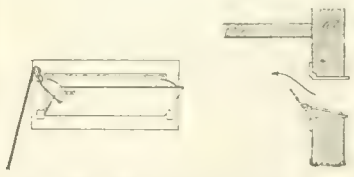


Fig. 3256.—Sheringham Valve. Front and sectional view. (Munson.)

The *Ridge Ventilators* consist (Fig. 3259) of

openings through the ceiling and roof of one-story buildings, with louvered sides and ends protected with a small roof; the opening of the air shaft in the ceiling is usually provided with a movable shutter to regulate the outlet. The fresh air is admitted by inlets running underneath the floor between the joists and discharging through a register near the stove, or it may be admitted by Sheringham's valves. Of the various methods used in artificial ventilation which contemplate a change of the weight of air without heating, attention is again directed to the perflating and aspirating effects of winds, which are so extensively utilized in the ventilation of ships, and are equally applicable to habitations. Here a large cowl is placed so as to face the wind and the air is thus driven below through a large pipe, whilst another cowl placed to back the wind acts as an aspirator to draw the bad air from below. A great many contrivances seen in connection with house ventilation, some with rotating cowls, others with fixed vanes, are based on this principle (Figs. 3260, 3261, 3262).

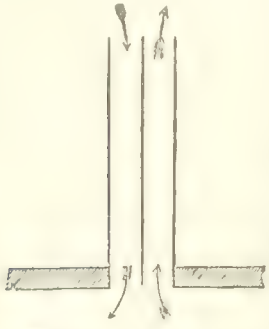


Fig. 3257.—Watson's Tube. (Munson.)

2. *Extraction by Heat.*—The simplest way to produce a difference between the temperature of the inner and that of the outer air is by heating the room by means of a stove or open fireplace, both of which will serve to extract the foul air and secure a thorough renewal of air. In some instances, the outlet can be placed in a separate flue next to the chimney flue; the latter being warmed creates an upward current. A simple and effective method is to let the iron smoke pipe from the furnace or heater pass through a brick or terra-cotta flue and connect the vent ducts from the rooms with the space between the smoke pipe and the flue; upon this principle the Eckstrohm ventilator is used for carrying off the kitchen fumes. Gas jets and lamps, or a steam aspiration coil, may be employed in connection with shafts used for the extraction of foul air by heat (Fig. 3263).

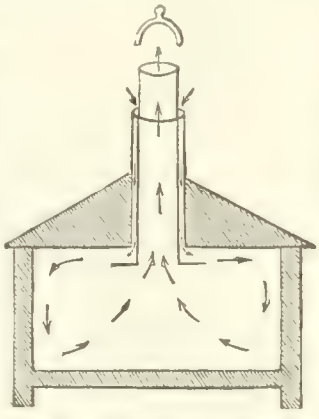


Fig. 3258.—McKinnell's Circular Ventilator. (Munson.)

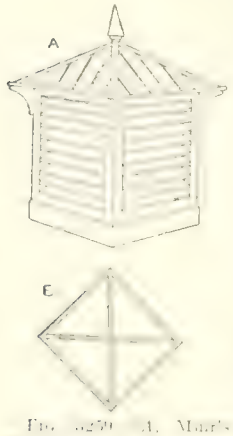


Fig. 3259.—A, Mott's Ventilator. B, transverse section of same.

3. *Propulsion and Aspiration.*—Another system especially adapted for large public buildings is to set the air in motion by the use of fans or air propellers.

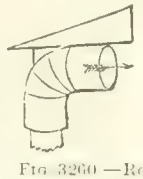


Fig. 3260.—Rotating Cowl for Aspiration. (Munson.)

In other words, the fresh air is forced into and distributed throughout the building while another fan exhausts the foul air. These fans are set in motion by water, steam, electricity, or other motive power. This method presents several advantages, the amount of air delivered and the rate of movement can be regulated with nicety, the entering air can be taken from any desired pure source and can be filtered, washed, warmed, or cooled. The Madison Square Theater, in New York City, according to Dr. D. F. Lincoln (Parkes' "Hygiene," vol. ii., p. 472), was one of the best ventilated buildings of its class. The air was taken in at a tower above the roof; was filtered through a conical bag of cheesecloth forty feet long suspended in the tower; it was heated by steam in winter and cooled in summer by passing over ice; heating, cooling, and distributing taking place in the basement. One fan at the foot of the tower forced the air into the audience hall, another on the roof exhausted it. The doors and windows were kept closed. The air was introduced by pipes running under the risers; an opening in the riser at each seat discharged a forward current with a velocity of two and one-half feet per second; other jets entered at the front of the footlights and below the balconies; the exits were chiefly under the balconies, so that there was a general movement away from the stage. For large buildings, the "Wing disc fan" (Fig. 3264) is usually employed, a four-foot fan using one-horse power delivers about 500,000 cubic feet of air per hour, while the larger sizes of the "Blackman wheel," according to Munson, are said to give about 12,000 cubic feet of air per minute (Fig. 3265).

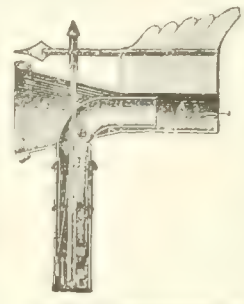


Fig. 3261.—Banner's Rotating Exhaust Ventilator (Munson.)

Fig. 3262.—Star Ventilator.

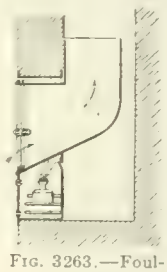


Fig. 3263.—Foul-air Outlet.

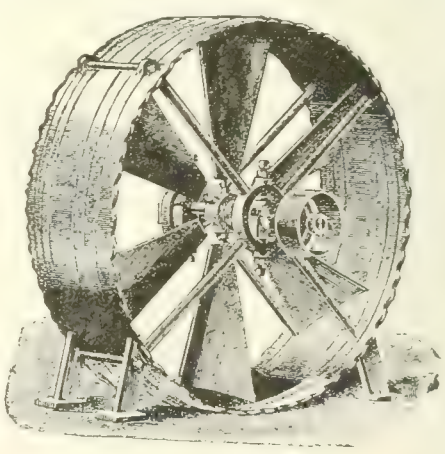


Fig. 3264.—Wing Disc Fan.

Hydraulic ventilators are extensively used during the summer months in Germany; they consist of U-shaped pipes containing spray nozzles under high pressure; the air is sucked in and propelled by the falling spray, the water collecting at the bottom and being discharged by a drain pipe. According to the degree of temperature of the water, the air may also be cooled by this method (Fig. 3266). Ventilation is also effected by the plenum or pressure method or by the exhaust method alone. It is important that the toilet rooms should be ventilated independent of the general system of the building, which is best accomplished by the method referred to on p. 347.

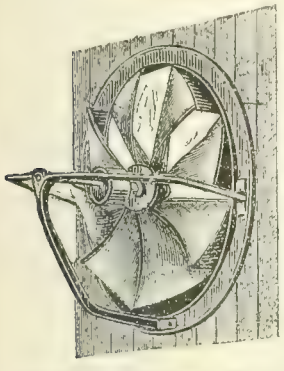


Fig. 3265.—Blackman's Wheel.

General Rules to be Observed in Ventilation.—1. The object of ventilation being to improve the air of the house, we should be sure of the purity of the incoming air. It should not be brought through underground ducts, nor from any point likely to be contaminated by sewer air or other noxious gases. The indication is plainly to select the safest spot for inlets; the inlets should be provided with valves to regulate the amount and protected with fine wire gauze or Hessian jute to exclude vermin and dust. Whenever practicable the air should not only be filtered, but also washed by means of a fine spray in its passage through the inlet. If the fresh air is too cold, it should preferably be warmed before entering the apartments by means of ventilating stoves or grates, or a central system of heating by furnace, steam, or hot water.

2. The superficial area of outlets should be at least as large as that of the inlets, and in order to insure renovation of air with the least amount of draught, the inlet and outlet openings should not be placed directly opposite but diagonal from each other. It is desirable to place the inlets about the middle height of the rooms and the outlets near the ceilings; they should be supplied with registers to regulate the amount.

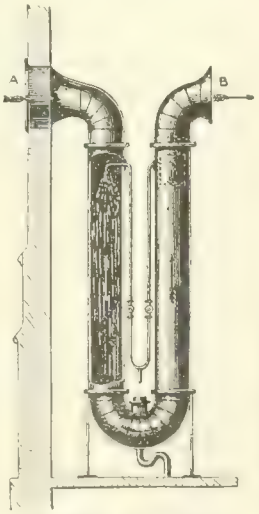


Fig. 3266.—Water Spray Ventilator. (Munson.)

3. Since every adult requires 3,000 cubic feet of fresh air, it must be our aim to see that this amount is supplied without discomfort to the occupants. The air of a room cannot be changed oftener than three times in one hour in winter without causing a disagreeable draught; hence every occupant should have a cubic air space of 1,000 feet. Finally this air space must not be furnished in height at the expense of superficial or floor space, for the reason that organic matters are not equally diffused but tend to accumulate in the lower strata; consequently excessive height (*i.e.* over twelve feet) does not mean a corresponding dilution. The question of proper air space has not been practically settled; while 1,000 feet is doubtless the ideal standard it is not always attainable, especially in the homes of the poor and in large assembly rooms, theaters, churches, etc. In the latter instances the air space is often less than 300 feet per capita, but the exposure is of a comparatively short duration. Hygienists appear to be satisfied that for all practical purposes from 400 to 500 feet of air space per occupant will suffice in the homes of the poor, lodging houses, etc., provided the air is kept in motion, and in view of the results obtained by the "out-door" treatment the danger of draughts has lost some of its significance, provided the sleeper is otherwise protected.

In conclusion, it should be distinctly understood that no amount of artificial ventilation can render thorough and frequent house-cleaning unnecessary, or the precautions for the exclusion of contaminated air superfluous, nor can ventilation in winter be maintained without the expenditure of considerable fuel. The question of systematic house-cleaning is important. We have learned that dust and germs are coincident hence there should be no accumulation in any part of the premises. Vacuum cleaners are unquestionably the most efficient means for the thorough removal of dirt and dust, when not available it is a good plan in sweeping, to open the upper sash and close the doors leading to the interior of the house, so that the dust may not be wafted into other parts of the house. Dust should be removed by means of damp cloths, or when articles are liable to be injured a dry dusting cloth should be chosen. Feather dusters are useless as they simply displace the dust.

Heating.—The necessity for artificial heat whenever the temperature falls below 70° F., notwithstanding the fact that a healthy adult gives off hourly eighty-eight heat units, is fully recognized, and hygiene requires that this artificial heat should be supplied as uniformly as possible, and that the air of habitations, instead of being vitiated by the products of combustion, should be improved by the heating apparatus.

Fuel.—For this purpose materials containing carbon and hydrogen, one gram of which is capable of evolving during combustion respectively 8,080 and 34,462 small calories, are used. Putzey's estimates of the heating value of various kinds of fuel are as follows:

Fuel.	Fuel value of one kilogram.
Dry wood	3,600 calories
Lignite	4,180 calories
Coke	6,000 calories
Charcoal	7,000
Bituminous coal	7,500
Anthracite	8,000
Petroleum	17,176
Illuminating gas per cubic meter	7,700

Of the foregoing fuels, white ash, Lehigh anthracite coal, and gas unquestionably permit of the most complete and ready oxidation of the carbon and hydrogen, which elements supply the heat.

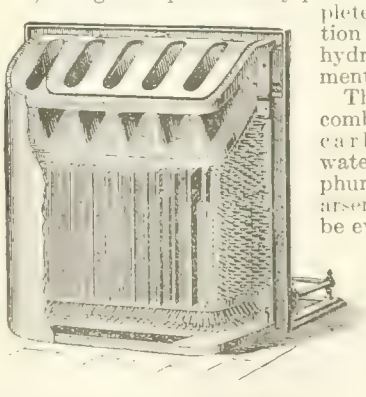


Fig. 3267.—Jackson's Ventilating Grate, Back View. The outer casing is cut away to show space and surface for warming the incoming air.

The products of combustion are chiefly carbonic acid and water, although sulphurous vapors and arsenical fumes may be evolved in the combustion of mineral coal. If the amount of oxygen is insufficient for free combustion, carbon monoxide, fine particles of carbon in the form of soot, tarry matters,

and carbureted hydrogen also escape. The smoke under such circumstances is therefore a mixture of C, CO, CO_2, H_2O, C_2H_2 and may also contain sulphurous and arsenical vapors.

Rooms may be warmed separately by stoves or fireplaces; this is called *local heating* in contradistinction to the system of *central heating* in which the heat is supplied to a number of rooms or the entire building from a central plant. The latter system offers so many advantages that it is rapidly superseding every other method, at least in cities. The majority of houses in rural districts, however, are still warmed by open fireplaces and stoves. Fireplaces are niches in the chimney supplied with grates in which combustion may be maintained and the products are rapidly carried off through the chimney. The room in this instance is warmed by *radiant heat*, which means the passage of heat from warm bodies to cold ones without raising the temperature of the intervening air directly; the latter is warmed by convection from heated objects. A uniform temperature cannot be maintained by the exclusive use of an open grate, and though a most excellent ventilating apparatus, it is too powerful to be wholesome, and is moreover quite wasteful, as five-eighths of the heat generated escapes up the chimney. The latter objection has been in a measure overcome by controlling the chimney current by a damper, and by a proper construction of the grate and fire-back. For this purpose the width of the grate at the back should be about one-third the width in front facing the room; the side walls of the fireplace should join the back at an angle of 45°, so as to throw as many heat rays into the room as possible, and for similar reasons the whole fireplace should be brought well forward into the room. To minimize these defects, an attempt has been made to surround the back and sides with a space through which air can pass and be warmed by the heat that would be otherwise wasted. An opening below admits fresh air into the chamber where it is warmed and escapes through an opening into the room above the mantle. The Galton, Jackson, and Joly ventilating grates are all constructed on this principle and are therefore a combination of hot air and fireplace heating (Fig. 3267).

Stoves.—There are an endless variety of stoves in which either wood, coal, gas, or petroleum is burned, and in which from seventy-five to eighty per cent. of the fuel is utilized. The great distinction between these and open fireplaces is, that the air which comes in contact with the heated surface is warmed, expands and rises, and its place is taken by a cold air; the currents of warm air circulate through the room and thus every part is equally heated. It is essentially heating by convection, although a very hot stove also supplies radiant heat. Stoves are made of wrought or cast iron, terra-cotta, porcelain, and soapstone; some are ordinary closed stoves, while in others provisions are made for the admission of fresh air from without, which is made to circulate through the stove without coming in contact with the products of combustion, and after being thus heated passes into the same room or the room above, as in our latrobes, ventilating grates, or the "Cortland Howe" ventilating stove (Fig. 3268). The principle of introducing fresh air can be applied by running a fresh-air inlet from the outer air to near the stove and surrounding the latter with a jacket of sheet iron. The inlet and corresponding outlets should be provided with registers. This is a very simple and effective method of heating and ventilating rural school-houses, etc.

Since gas, both natural and artificial, and coal oil are being extensively used in this country for both heating and cooking purposes, it may be stated on the authority of Notter and Firth that when the combustion is complete and the ventilation is sufficient for the ordinary effects of respiration, their use is not fraught with danger, especially when the more improved patterns are used; but the larger oil stoves or gas stoves which burn more than five feet of gas per hour should be provided with a flue to carry the products of combustion to the outer air. The ordinary gas logs set in fireplaces or the "Backus portable steam radiator" for use with gas should be preferred.

Heating by electricity possesses many hygienic advantages, but the excessive cost has so far prevented its general use.

Central Heating (Furnace).—A very common way to heat a modern dwelling is by the use of a hot-air furnace. In such a case a furnace of wrought or cast iron, brick, or soapstone is placed in the basement; the fresh air is admitted from a pure source into the air chamber of the furnace where it is heated and conducted in suitable-sized flues to the different rooms and stories of the house. According to Mr. Edward S. Philbrick ("Man. of Pract. Hygiene," Parkes, vol. ii., p. 466) a house of more than three large rooms on the floor, however, with one or two stories of rooms

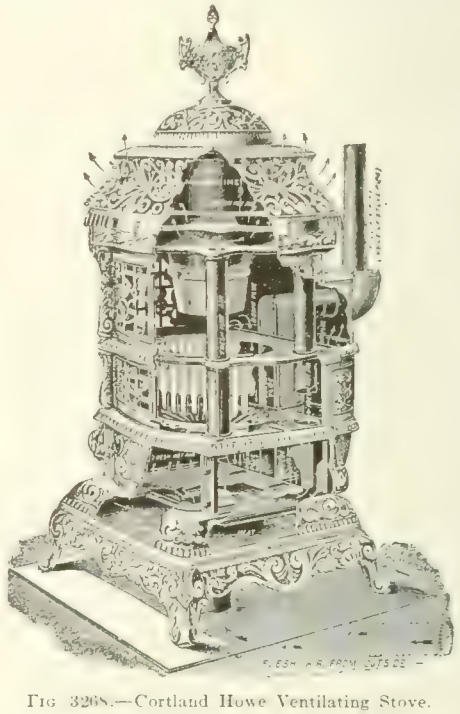


Fig. 3268.—Cortland Howe Ventilating Stove.

above, cannot be properly heated by only one furnace, as it is almost impossible to conduct heated air more than six feet in a horizontal direction from the furnace. The combination of a hot-air furnace and open fireplaces is believed to be a very sanitary way of heating a house, because provision is thus made for both inlets and outlets; the latter are often neglected. An open fireplace is very useful in drawing the furnace air down to its own level, even when there is no fire actually burning in it. All this is important, for apart from the fact that outlets should exist for the extraction of foul air, a windward room cannot be warmed because the furnace air refuses to enter it, and the remedy for this is the open fireplace, or the opening of a chimney flue in the room. Flues from furnaces supplying different rooms sometimes draw against each other, especially when the supply from below is not sufficient for all, either because the fresh-air inlet to the furnace is too small or because after it has been closed in a high wind some one has neglected to open it (Lincoln).

The objection to cast-iron furnaces and stoves is that carbon monoxide is believed to escape through invisible fissures in the plates and joints, while the heaters are red hot, hence they should be lined with

fire clay; this precaution may not be necessary for the escape of CO, but it will improve at least the quality of the heat. Soapstone furnaces are highly praised for the quality of the air. Since all heaters are liable to render the air too hot and dry, they should be provided with evaporating pans, or, what is even preferable, a larger heater should be chosen which will not have to be raised to red heat and at the same time furnishes a larger volume of warmed air. If the air is superheated it acquires a peculiar odor, probably due to charring of organic dust; it also becomes very dry and irritating owing to the rapid evaporation of moisture from the skin and mucous surfaces of the inmates and in consequence is apt to produce catarrhal affections, conditions which do not prevail when the temperature of the air delivered does not exceed 90°. There is also economy in running a stove or furnace at a moderate rate, and a reserve should be on hand for colder weather. Dampers in the smoke flues of heaters are always objectionable; the joints of the draft doors should be so good that opening and closing of the lower door or slides is sufficient, but as long as these joints are imperfect, dampers are a necessary evil.

Heating by Hot Water is now extensively employed in modern homes and even larger buildings and while more expensive than the first cost of hot-air furnaces and a steam-heating plant, the advantages are economy in fuel and repairs; the temperature is more agreeable and the heat can be conducted to any desired point. In the *low-pressure system* the pipes are connected with a boiler so as to provide a complete circulation. The exact size of the pipes depends upon the amount of radiation necessary; one square inch of area in the mains supplies 100 square feet of radiation provided the length of the run does not exceed 100 lineal feet. The water after being heated circulates through the pipes and radiators, parts with more or less of its heat to the air, *i.e.* heating by convection, and returns to the boiler. At the highest point of the system an expansion tank is placed, and a small escape pipe is carried into the outer air to give vent to steam and hot air. The water rarely ever attains a higher temperature at any part of the system than 200° F. (Fig. 3269).

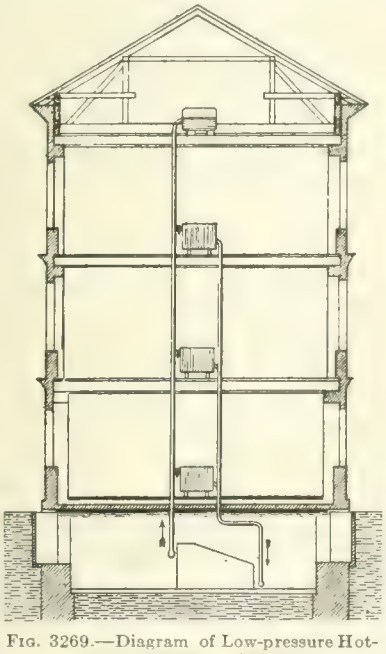


Fig. 3269.—Diagram of Low-pressure Hot-water System. (Munson)

In the *high-pressure system* the pipes are smaller, about one inch in diameter, but sufficiently strong to withstand the pressure incident to a very high temperature, as from one-tenth to one-sixteenth of the coils are exposed directly to the heat of the fire. The water being completely enclosed from the outer air, attains usually a temperature of 300° F. and circulates more rapidly; provision is made for expansion by larger pipes at the top of the system. With the low-pressure system thirty-three square feet of radiating surface for every 1,000 cubic feet are required to raise the temperature of the room to 70° F. at zero weather, while with the high-pressure system about twelve square feet are sufficient. The volume of water in the high-pressure system is very much less and is heated therefore more quickly than in the low-pressure system, but it will also cool more quickly, and on the whole the advantages are in favor of the low-pressure system, because the temperature is more uniform and there is no danger from explosions or superheated pipes.

Steam Heating is employed in many public and private dwellings and the waste steam of locomotives is utilized in the warming of cars, ships, and factories. The methods have been perfected and the danger from explosions reduced to a minimum; nevertheless steam plants, as well as other central heating apparatuses, require careful planning and intelligent supervision. Steam heat, like furnace heat, is apt to be excessive in mild weather, but the temperature can be regulated by arranging multiple coils or radiators, which can be shut off in sections. In every case the caliber of the radiator should be larger than the supply pipes so as to favor condensation and consequent liberation of latent heat. Provision must also be made for the rapid return of the condensed vapor to the boiler by means of return pipes, since any obstruction to the flow of the return steam interferes with a free and rapid circulation and causes not only defective heating but also a most disagreeable thumping noise.

In connection with either hot water or steam heating, we recognize three methods: (1) the direct; (2) the indirect; and (3) the direct-indirect. In the direct system, the radiators are placed in the room without any special provisions for ventilation; in the indirect system, the coils or radiators are placed in a suitable chamber in the basement into which fresh air is admitted and from which the heated air is distributed to the different rooms by suitable inlets and outlets. This plan answers very well for ordinary dwellings, but for larger buildings arrangements must be made to force the heated air where wanted, and this is accomplished by the *exhaust system*, or the *plenum system*. In the former, the air is exhausted by suction and the pressure of the atmosphere is relied upon to replenish the fresh air, while in the plenum system the air is forced into the room by special fans, and is preferable because the purity and volume of the air can be regulated in the manner already referred to under Ventilation. In the *direct-indirect* system, the radiators are placed under the windows and the fresh air is admitted from behind them and is warmed by its passage over the radiators. The fresh-air inlets are controlled by a key in the room connected with a register outside in order to regulate the amount of fresh air, while the foul air is discharged by suitable outlets. The air in steam- and hot-water-heated apartments may also become excessively dry and evaporating pans are almost as essential as with furnace heat. With automatic thermoregulators, it is possible to maintain a uniform temperature, and on the whole we may conclude that the indirect and direct-indirect systems—combining, as they do, a central system of heating with proper ventilation—are the most sanitary. The use of steam gives perhaps more satisfactory results in cold climates than the hot water, but either method is preferable to hot-air furnaces.

Vacuum or *Vapor Heating* is gaining favor of late. It possesses some advantages over either steam or hot water, in that it operates at practically hot-water temperatures while free from the danger of leaks and freezing. The valves employed are so constructed as to permit regulating the amount of heat by turning on one or more parts, making the control almost perfect. This system requires hot-water radiators and proportionately large pipes. In all systems, the boiler should have a capacity fifty per cent. in excess of the

total radiating surface, to provide for exposed piping and other losses. All main and return pipes should be insulated with asbestos sectional covering. The casings of indirect radiators should be so constructed as to give access for cleaning purposes. Floor registers should be avoided as they act as dust and germ traps. All radiating surfaces should be freed from dust from time to time.

Lighting.—Apart from the hygienic importance of sunlight on metabolism and its destructive effect on germ life, every room, whether used for dwellings, workshops, schools, etc., should be so well lighted by windows that the eyes need not be strained even on a cloudy day.

Natural Lighting.—The area of windows, exclusive of sash frames, should be at least one-sixth or preferably one-fifth of the floor space, and in order that the light may penetrate the deeper portions of the room, the windows should almost reach to the ceiling. After providing the windows we should, of course, not shut out ninety per cent. of the light by blinds and draperies; but if the light is too glaring it may be softened by white, cream, or light gray shades; the color of the window panes should always be perfectly transparent; plate glass possesses the advantage of warmth and durability. The difficulty of securing a sufficient amount of daylight in buildings located on narrow streets surrounded by tall buildings has been partly overcome by glass building blocks $8\times6\times2\frac{1}{2}$ inches, with an air chamber in the center, used, instead of brick or stone, in connection with steel frame construction, but more particularly by the introduction of prisms, which refract and diffuse the light throughout a room that would otherwise be illuminated but partially or not at all.

Fig. 3270.—Welsbach Burner.

Artificial light, no matter how obtained, differs from daylight in this, that it does not furnish a pure white light; the prevailing rays are red, yellow, or violet, and the effects of a yellowish-red or violet-blue are produced. Whatever difference of opinion there may be as to the color best suited to our eyes, we know that our vision is most perfect under the influence of a white light, and this ought to be a good criterion. One of the disadvantages of all low-power illuminants is that the light is never as bright as daylight, involving therefore closer application of the eyes and consequent strain of the muscles of the eyeball. These remarks are hardly applicable to the electric arc-light and the Welsbach gas-burner, the rays of which, like the direct solar rays, may indeed be so glaring as to cause undue irritation of the retina. Another harmful effect of artificial illumination is the unsteady or flickering character especially seen in the electric arc-light, and which on account of the abrupt changes is likely to irritate the retina; another disadvantage is that the ordinary illuminants, except the electric light, tend to vitiate the air by the products of combustion and also affect the temperature and humidity of the air by the heat evolved. The requirements of a hygienic light are that it should be as near as possible the color of sunlight sufficiently ample, but not too glaring it should be steady and instead of deteriorating the air, it should as far as practicable be utilized to improve the air; nor should the heat evolved be sufficiently intense to be a source of discomfort to the inmates in warm weather.

From this table we conclude that the electric arc-light is the most suitable for lighting of streets and squares, the electric incandescent light is best suited for public and private habitations, including also steamers, powder works, and mines. The modern tendency is toward the use of tungsten filament incandescent lamps even for street lighting; indeed the tungsten filaments have practically superseded those made of carbon for all purposes, possessing a far greater efficiency and life. Frosted globes have done much to promote eye comfort and refracting shades help not only in this respect, but where general lighting is the object, they vastly increase the efficiency. Indirect lighting in which lamps are practically out of sight is now being installed in modern buildings. Nothing can be said in favor of the mercurial vapor lamps.

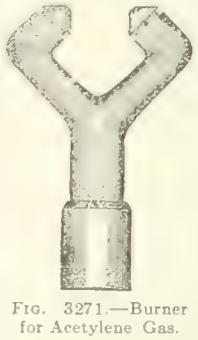


Fig. 3271.—Burner for Acetylene Gas.

Electric light is in every way superior to gas and other illuminants, because there is no danger from fire, there are no products of combustion, hence no pollution of the air, nor are the temperature and humidity of the rooms affected to any perceptible extent. These advantages over gas are of special importance to the inmates of buildings where the question of fresh air and temperature play an important rôle; hence we can readily appreciate that banks and other institutions find it profitable to install electric lighting and save time and money by the prevention of sickness among their employees. Next to electric light, gas, especially in connection with a Welsbach or Siemens burner, offers the next best choice; in the absence of either, kerosene with a high flashing point should be preferred over other illuminants. The flashing point of refined kerosene is defined as the temperature at which a sample of the oil commences to give off sensible quantities of inflammable vapor; it should not be less than 100° F. and a higher temperature is preferable. Explosions may occur in lamps when from any cause the vapor over the oil in the reservoir is lighted by a spark, as for instance when the wick is extinguished by blowing over the chimney and is then depressed in

Summary of the Most Important Characteristics of Illuminating Agents

Illuminants.	Quantity consumed	Color.	Candle power.	Oxygen removed. Cubic feet.	CO_2 produced.	Moisture produced. Cubic feet	Heat calories produced.	Vitiation equal to adult.
Tallow candles	2,200 grains..	Red yellow.....	16	10.7	7.3	8.2	1,400	12.0
Sperm candles	1,740 grains..	Red yellow	16	9.6	6.5	6.5	1,137	11.0
Paraffin oil lamp	992 grains...	Red yellow	16	6.2	4.5	3.5	1,030	7.5
Kerosene oil lamp	909 grains	Light red yellow	16	5.9	4.1	3.3	1,030	7.0
Coal gas, No. 5 batwing burner	5.5 cubic feet.	Light red yellow	16	6.5	2.8	7.3	1,194	5.0
Coal gas, Argand burner	4.8 cubic feet	Light red yellow	16	5.8	2.6	6.4	1,240	4.3
Coal gas, Siemens regenerative	3.2 cubic feet.	Yellowish-white	32	3.6	1.7	4.2	700	2.8
Coal gas, Welsbach.	5.5 cubic feet	White	50	4.1	1.8	4.7	763	3.0
Acetylene	1.0 cubic foot	White	50		2.0			3.6
Electric incandescent light	4.3 cubic feet	White.....	16	0.0	0.0	0.0	37	0.0
Electric arc-light.....	..	Blue violet.....	100		0.0004			...

a smouldering condition, or when the chimney of the lamp is broken. The Duplex and Rochester burners and many other safety lamps have reduced these dangers to a minimum. The dangers from the inhalation of carbon monoxide from leaky gas fixtures and pipes are especially great when water gas is used, on account of the total absence of odor. Of the various gas burners, the Welsbach, Siemens, and the Argand burner enclosed with a chimney give the best results. Wherever practicable, provisions should be made to carry the products of combustion to the outer air, and thereby aid in ventilation.

Acetylene gas has come into deserved prominence, and as it can be generated for individual households at a comparatively slight expense, and has many excellent qualities, it is likely to grow in favor. It is a colorless gas (C_2H_2) with a characteristic unpleasant odor, and is generated by the action of water on calcium carbide in a special apparatus, suited to the needs of the respective household or building. Munson states that "a generator capable of thoroughly lighting a company barrack or post hospital need not be greater in bulk than a hogshead, while one capable of illuminating a field hospital of one hundred beds is not larger than a pork barrel." The gas requires a special tip and combustion is usually complete (Figs. 3271 and 3272).

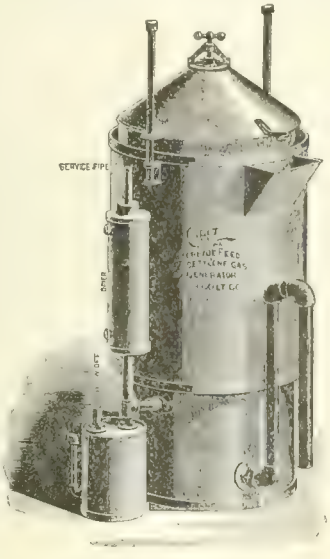


Fig. 3272.—Large Size Acetylene Generator. (Munson.)

Gasolene gas.—Gas may also be made from gasolene for isolated lighting systems, and since it can be used for cooking purposes by means of an ordinary gas range, it is specially adapted for country homes, single houses, or even groups of houses. The gas is a mixture of gasolene vapor and air, generated and forced through the system by means of a special apparatus requiring no expert skill but simply ordinary precautions as the gas is very inflammable.

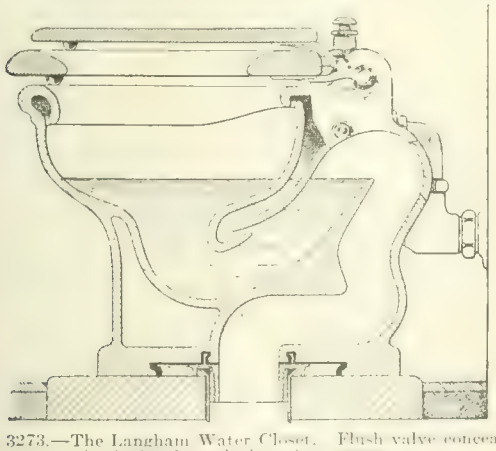


Fig. 3273.—The Langham Water Closet. Flush valve concealed in the bowl, no flush tank necessary.

Water Supply.—In cities furnished with a general water supply, every floor should be provided with water taps, not only for convenience, but also for greater safety in case of fire. In isolated houses and villages without a general supply or a good spring in the vicinity, our choice will be between artesian, cistern, and well water. On general principles preference should be given to artesian water. (See article on *Water*.)

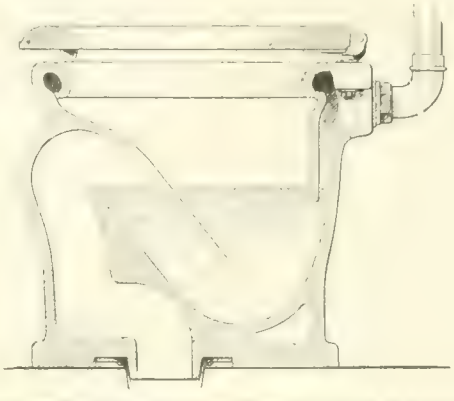


Fig. 3274.—The Torrento Water Closet, showing in sections the syphon-action wash-down bowl.

There are a number of pneumatic water-supply systems run by hand, gasolene, or other power, which pump the water either directly from the source of supply to the fixtures, or to a roof-tank from which the water gravitates to all parts of the house. The hydraulic ram is a simple and efficient device, where water is taken from a stream with sufficient fall to generate the necessary power. These together with a proper system of sewage disposal make modern plumbing fixtures available even in the most isolated localities.

Fig. 3275.—The Beekman Water Closet; showing siphon-jet bowl with push-button and low-down vitreous flushing tank.

House Drainage and Plumbing.—The object of the sanitarian is to remove as rapidly as possible all excreta and refuse from habitations, so that the air,

water, and soil shall not be made impure. In any event the accumulation must in no case extend so far as to render putrefactive changes evident to our sense of smell. The various methods for the disposal of sewage will be discussed in a separate article, and for the present suffice it to say that the most sanitary disposal of the flow from the water-closets and house drains is a well-devised system of sewerage, which will convey the flow on to farm lands or into the sea, but not into watercourses used for drinking purposes. Since this system begins in the habitations, we shall point out the requisites for proper house drainage, which consist of:

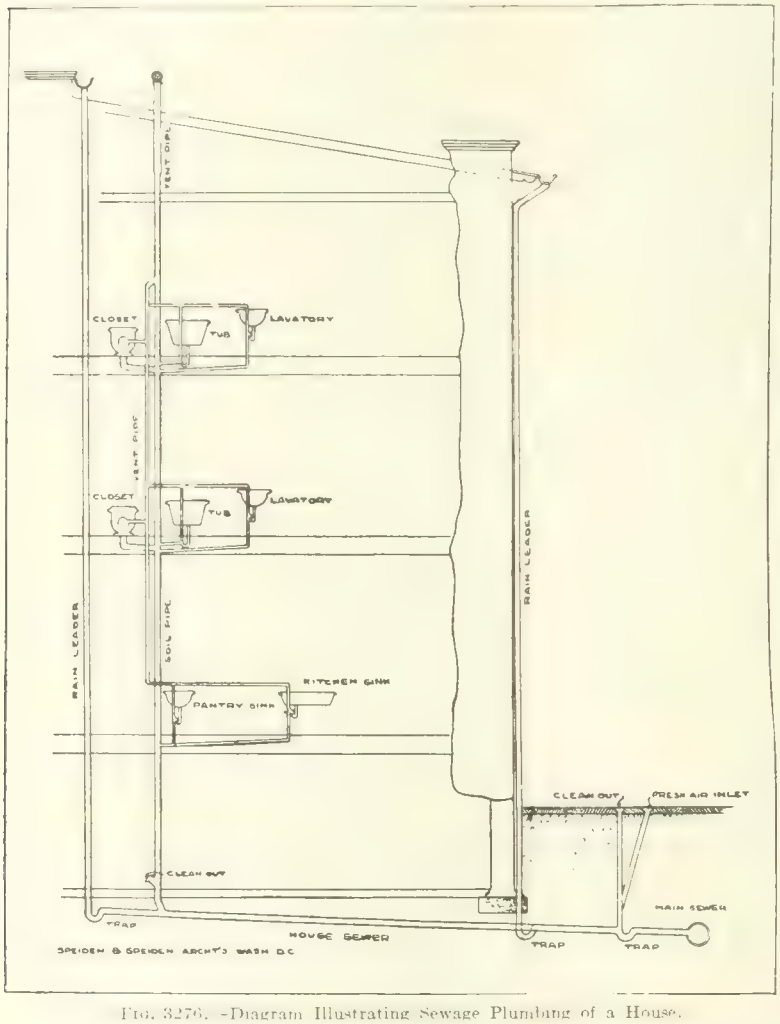


Fig. 3276.—Diagram Illustrating Sewage Plumbing of a House.

1. Water-closets and urinals, wash basins, bath and laundry tubs, and kitchen and slop sinks;

2. A perpendicular system of piping known as the soil and vent pipes with which the foregoing fixtures are connected; and

3. The house drain, which is a nearly horizontal pipe, and connects the system with the sewer or cesspool.

Water-closets consist of an apparatus for the reception of excreta connected with the soil pipe by means of a suitable trap, and in which water is used to dilute and carry away the excrement deposited therein. They are classified under two heads, viz., those having a trap integral in the ware and a water surface for the reception of excreta and those without the trap and having no water surface. Under the first head are included the "wash-out," "wash-down," and "siphon-jet" types of water-closet bowls. Under the second head are embraced the plain or "dry" hoppers. The pan, valve, and plunger closets are now obsolete. The plain or dry hoppers are used only where subject to freezing and are unsanitary for indoor use. The wash-out bowls and trapless hoppers are prohibited in modern plumbing regulations. The siphon action wash-down and siphon-jet bowls are now generally used; the latter being more sanitary, because its construction allows a larger water surface, deeper water seal, and also quicker removal of the contents of the bowl when flushed. The wash-down bowls have a smaller water area and having no jet are sluggish in operation. Vitreous glazed earthenware is the material of which almost all water-closet bowls are now made. Enameled-iron closet bowls are prohibited for interior use by the plumbing regulations of almost every municipality. These fixtures are designed to give a quick and powerful flush of five or six gallons of water from a tank, the siphon of which is set in action by pulling a chain or lever or by a push-button device. Flush valves of a lever or push-button type, which operate directly from the water supply without the use of flush tanks, are also in use. The low type of tank has replaced the high pattern and vitreous earthenware material is used in lieu of the copper-lined wood or enameled iron tanks. The connection between the closet bowl and the waste pipe at the floor is important. The putty joint or common rubber gasket are unsatisfactory on account of their liability to leak and should give way to screw-joint connections. The manufacturers of plumbing fixtures, notably the J. L. Mott Iron Works of New York City, have made great progress in this field and have produced a variety of styles which are very satisfactory. (Figs. 3273, 3274, 3275, also Figs. 3276 and 3277.)

Where the closet is to be used by servants, children, and others likely to neglect the flushing, the water supply should be made automatic and metered by a waste-saving apparatus. The weight of the person on the seat is thus made to lift the valve in the bottom of the tank and when the weight is removed this valve closes and the lower one opens, discharging an ample and definite quantity of water with a sudden dash, which expels all the contents of the hopper below. For public buildings, copious flushes discharged at regular intervals from automatic flush tanks are to be preferred. No system should be tolerated which provides for the flushing of the hoppers by faucets, for even if allowed to run for half the time with the consequent waste of water, it does not flush the system like the sudden dash of five or six gallons of water. Devices such as the "Flushonette," or the closet illustrated in Fig. 3273 are not open to this objection if the flush pipes are of sufficient size and operate either with the full pressure in the street mains or from a tank at the top of the house, arranged to fill

Fig. 3277.—Bathroom "Plaza."

Fig. 3278.

automatically. These devices can be set to flush with any desired quantity of water.

Water-closets whenever practicable should be located in a separate room from the bath-room, and preferably in a special projection connected with the house by a well-ventilated lobby; the compartment should be provided with a window and other outlets, so that the air may find a ready exit without contaminating the air of adjoining rooms. The exhaust flue already referred to (Fig. 3263), and heated by either an aspiration coil gas jet or lamp, is especially indicated in rooms used for water-closets. Each floor of the house, if great convenience is desired, should have such a room and an adjoining room large enough for the bathtub, lavatories, slop sinks, etc. (See plans on page 338.)

Simplicity of the drainage system is of the utmost importance; hence all the fixtures necessary for the comfort of the inmates of the house should be placed in close proximity to the soil pipe, drained and trapped separately into the soil pipe. An error frequently made is to connect a wash bowl waste with a water-closet trap several feet distant by a pipe under the floor, difficult of access and so nearly horizontal as to insure its being soon filled with a deposit of slimy filth. This, like the scattering of fixtures all over the house, is very objectionable. When it becomes necessary by reason of inability to place the required number of fittings in the soil pipe at any point, the fixture should be so located as to insure a short run and ample fall for the waste pipes. The lead bends connecting water-closets with the "soil stack" should weigh not less than eight pounds per lineal foot. A well-planned, moderate-sized house will show all the bath-rooms, water-closets, pantry, kitchen, and laundry fixtures directly above one another and in close proximity to the soil pipe; that is to say, the rooms used for servants' bath-room and laundry in the basement should correspond with the kitchen and pantry on the first floor, and the toilet rooms and water-closets on the upper floors. (See the diagram shown in Fig. 3276.) All the plumbing should be exposed, and since the introduction of nickel-plated pipes, the various fixtures present a very attractive appearance. Copper-lined wooden bathtubs and encased wash bowls and water-closets have given way to open elegant and durable fixtures of porcelain or enameled iron. The ordinary water-closet with hinged seat can be used for a urinal. Bathtubs built one inch into the floor and into rear end and side walls are the most sanitary type and are coming into general use, since they obviate the spaces under and around the tub in which dirt is liable to accumulate. The tendency in the production of plumbing fixtures is also to minimize, as far as practicable, the amount of nickel and brass piping. See illustration (Fig. 3277) of a bath-room as provided throughout the Plaza Hotel, New York City. The bathrooms and other rooms containing plumbing should have an impermeable floor, such as the "granito" floor already referred to, while tile or adamant walls are also desirable.

Urinals should always be of some non-corrosive

material, such as china, stoneware, or slate; public urinals should be provided with automatic flushing tanks or a "flush-down spray" (Fig. 3278) and an impermeable floor sloping toward a gutter which discharges into a siphon trap connected with the soil pipe.

Kitchen, pantry, slop sinks, and laundry tubs are usually made of earthenware, porcelain, slate, soapstone, or iron—galvanized or enameled, and are protected with a strainer to keep the large foreign bodies from obstructing the pipes. Whenever the kitchen and pantry drains cannot be provided with a very rapid fall, the congealing of the grease is likely to form a deposit on the inside of the pipe which often obstructs it entirely. To remedy this condition, which will arise no matter how large the drain pipe, the drain should be flushed with a hot four-per-cent. solution of caustic potash or soda several times a week, or what is far better, so-called "grease interceptors" are placed as near the sinks as possible. These devices consist of cast-iron fixtures holding several gallons of water which is cooled by an integral outer chamber through which the cold water supply to the sink passes. The grease congeals in these traps, which have easily removable covers so that the accumulations may be readily extracted. (See Fig. 3279.)

Soil Pipes.—The soil pipe forms a vertical stack inside of the building, extending from the house drain through the roof where it should terminate ten feet away from all windows and chimneys. The soil pipe receives the sewage from the water-closets and the waste water from all other fixtures; it should never be less than four inches in diameter, made of wrought or cast iron and painted with a coat of tar within and without. Special rules are laid down for the construction of the joints between the different lengths; they may be screwed together, or what is more common caulked with oakum and lead and Spence's metal. Screw joints are preferable. In any event they must be air- and water-tight and free from all defects. It is important to see that the soil pipe,

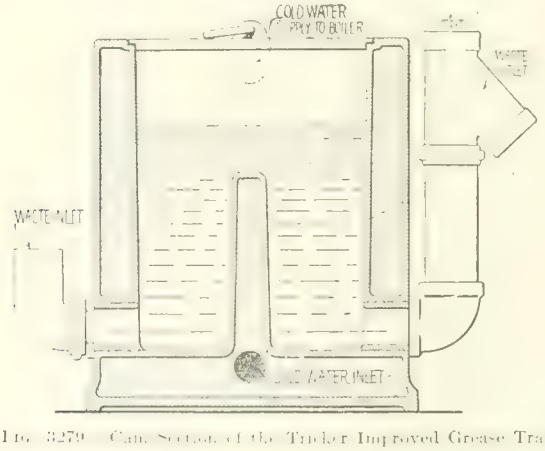


Fig. 3279.—Cast Section of the Tucker Improved Grease Trap

where it connects with the house drain, has a substantial brick or cement foundation and is properly stayed, for if not properly secured it may, during the settlement of the walls, strain one or more of the connecting joints and produce mischief by leakage. The connection between the soil pipe and house drain should be made by means of a rounded elbow and not by an abrupt right angle (Fig. 3280). At this junction a screw plug should be inserted for inspection and cleaning, as obstructions are most likely to occur at this point.

Traps and Ventilation of Soil Pipes.—It will be readily understood that if the fixtures were simply connected by means of ordinary drain pipes to the soil pipe, the air of the house would certainly be contaminated by sewer air and the more objectionable emanations from the soil and house drains, which are constantly coated with a slimy putrescible mass, giving rise to dangerous and offensive gases.

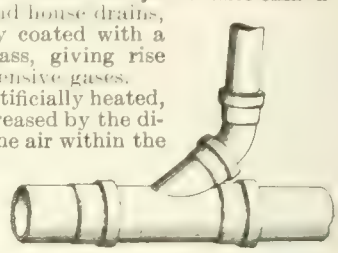


Fig. 3280.—Method of Connecting Soil Pipe with House Drain.

When houses are artificially heated, this tendency is increased by the diminished density of the air within the house, causing slight inward pressure through all existing openings and fissures. The remedy consists, first, in the use of traps which are certain appliances so constructed as to form a water seal of at least three-quarters of an inch, standing above the highest level of water in the curve of the trap. This water seal prevents the back flow of gases. There are an endless variety of traps in the market, such as the siphon, "Sanitas," midfeather trap, bell traps, etc. (Figs. 3281 to 3287), but of these Figs. 3281, 3282, and 3285 are the simplest and best, because there are no corners or angles for the accumulation of filth and the whole curve is always full of water. The water seal may be broken by evaporation when the fixture is not in constant use; this in warm weather may occur within a few days, and to reduce the danger to a minimum Mr. Putman invented the "Sanitas trap" which has given excellent results. Evaporation may also be prevented in unoccupied houses by pouring a little oil into the fixtures. It is desirable, however, upon reoccupying a vacated house, to flush all the fixtures with water and air the rooms, as sewer air may have entered. Traps may also be emptied by reason of capillary attraction, which is liable to occur if bits of rags and strings have found access to the trap, and one end passes over the further bend while the other remains immersed in the water seal. The water seal may also be broken by a heavy rush of water through it from its own fixture (*"siphonage by momentum"*) or by a rush down the soil pipe from a fixture on a higher level, *"siphonage by suction."* As an additional precaution against the entrance of sewer air and the unsealing of traps by siphonage, the soil pipe and traps should be ventilated. For this purpose the soil pipe is carried above the roof, the top being left open or protected with wire gauze or a ventilating cap, and fresh air is freely admitted to the drain at its lower end on the house side of the trap which connects the system with the sewer. The fresh-air inlet terminates above the ground and must be protected by a perforated iron plate to prevent obstruction, and as the air of

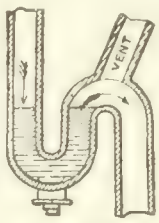


Fig. 3281.—Vented Trap.

Fig. 3282.—"Sanitas" Non-vented Trap.

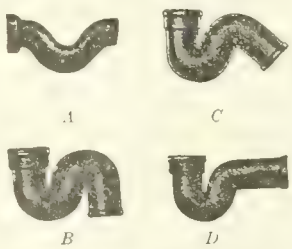


Fig. 3283.—*A*, Running trap; *B*, S-trap; *C*, three-quarter S-trap; *D*, half S-trap.

the house is generally warmer, a constant upward current is thus secured, except when the closet is used, when the current is reversed on account of the sudden rush of water downward through the pipe. For this latter reason and on account of the frequent obstructions placed in the fresh-air inlet by playing children and the obstructions found in the running trap, there has been a disposition to abandon the fresh-air inlet and running trap altogether. If the houses are constructed of uniform height, as is usually the case in modern city blocks, or if they are isolated from each other as in suburban localities, emanations from the soil pipe openings cannot injuriously affect the occupants of neighboring premises.

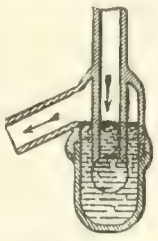


Fig. 3284 — Bower's Trap.

That even more radical opinions than those here expressed are entertained by eminent sanitary authorities is evidenced in a report of the Sewerage Commission of the City of Baltimore, rendered in November, 1896, by Messrs. Rud. Hering and Samuel M. Gray, who say:

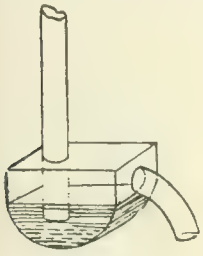


Fig. 3285.—D-Trap. (After Notter and Firth.)

"The problem of sewer ventilation resolves itself into a provision for maintaining a direct communication between the air in the sewers and the atmosphere and in causing the entrance of pure air and its circulation through the sewers to be as free as practicable.

"The most perfect way of accomplishing the above conditions is to ventilate public sewers through the house drains and soil pipes of the buildings, to omit the main trap along the house sewer which also acts as a retainer of foul matter, and to have perforations in the manhole covers of the public sewers.

"In this way an abundance of air can enter the system not only from the outfall, but through the manhole covers and circulate through the sewers and, out through every premise sewer to above the roof of the buildings.

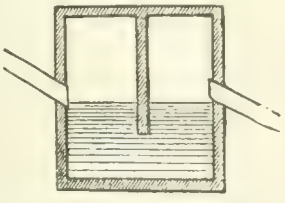


Fig. 3286.—Mid-feather Trap. (Notter and Firth.)

"Such a method of ventilation, however, requires that the entire plumbing in the house is planned and constructed by responsible parties, so that the work will be first class. It is also necessary to have the house pipes tested after the plumbing is finished so as to be assured of tight joints. This method has been tried in several cities in our country and is the common one on the continent of Europe, but it is not the usual one in our country, for there is in the minds of many a fear that if the public sewer should be ventilated through the soil pipe of their house, some danger might arise through a leak in their own pipes of contracting a disease, the germs of which are supposed to come from the public sewer.

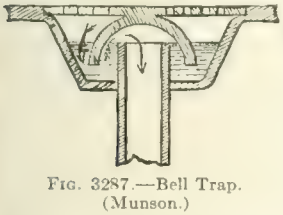


Fig. 3287.—Bell Trap. (Munson.)

"From experience in our country and in Europe, these fears are not well grounded and there are no facts on record to justify them. On the other hand, the advantages of a thorough draft through the house pipes is considerable and keeps them much cleaner than where a trap is placed between the house and the sewer, thus disconnecting the two.

"It has been said that air coming out of soil pipes below windows of adjoining houses might cause offence. But offence could also be caused if there were a main trap and the house pipes were fouled, which they generally are not when used for ventilating the public sewers."

There is much to be said in favor of both sides of the question although the plumbing regulations of many cities now make the use of the running trap optional.

The need of draft through every part of the house drainage is not the only reason, for, as pointed out by Mr. Philbrick, it is impossible to retain the water seal in the best forms of traps, unless the atmospheric pressure is freely admitted just below the water seal.

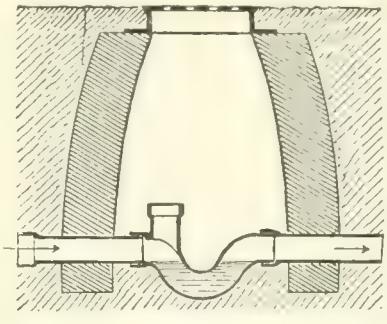


Fig. 3288 — Main Trap and Air-hole for House Drain.

The partial vacuum that follows a charge of water as it descends a vertical line of pipe is such that without a free admission of air below every trap, the pressure on the house side of the trap would force the water through them and leave them unsealed. It becomes necessary, therefore, to apply branch vents to each separate trap, for waste pipes more than eight feet in length and less than four inches in diameter. These vents should be extended from the drain below and above the roof or at least be extended and connected to the main soil pipe above the highest fixture. Mr. Putnam and others insist that trap venting does not cure siphonage and simply favors evaporation and necessarily increases the cost of plumbing, and to overcome this fault and still prevent the danger of siphonage, he prefers the "Sanitas trap."

Down spouts from the roof should never be used as soil pipes or ventilators, for apart from the danger of frost in certain climates, during heavy rains, when generally it is most necessary to give a safe exit on account of sewer air pressure, they will be absolutely useless as ventilators and foul air may be forced into the houses.

The *house drain* receives the discharge from all waste and soil pipes and conducts it to the sewer; formerly they were made of terra-cotta in four-feet lengths and laid in cement, but owing to so many fractures caused by the settlement and weight of the walls, the insinuation of roots of trees between the joints, rat burrows, etc., the building regulations very properly require that they also shall be made of cast iron, well-jointed, the diameter depending upon the number of soil pipes and rapidity of the fall. The fall for a four-inch drain should if possible be not less than one in forty, of a six-inch drain one in sixty, and of a nine-inch drain one in ninety feet; this will insure a velocity of flow in each case of between three and four feet per second. A direct line from the house to the sewer should always be chosen; if a bend is necessary a suitable curve should be described; the place where

the drain emerges from the house must be well cemented to exclude rats from the sewer. All branch drains should be made to connect with a Y, so that the branch current may be flowing as nearly as possible in the direction of the main current; these branches, if the plumbing is properly planned, will be necessary only for large houses. The water from the rain leaders should when practicable discharge at the head of the house drain, so that the drain may be thoroughly scoured during each rain storm. When drains discharge into a sewer liable to flooding, it is necessary to provide a tide valve between the sewer and drain, and for house drains with insufficient fall it is advisable to place an automatic flush tank at the head of the drain.

General Considerations.—It is perhaps needless to insist that sanitary plumbing involves a carefully planned system, good material and workmanship, simplicity and exposure of the work. Even the soil and drain pipes should be exposed when practicable, or at least should be accessible by panel work and covered channels in the basement. No soil pipe should be carried on the outside of the building in climates subject to frost, and to render a house safe from the contamination of sewer air it is necessary, first, that the soil pipe and all traps be ventilated; second, that the water seal in the traps be maintained, and third, that the entire system be free from leaks or defects.

Testing of Plumbing.—Soil pipes and the general plumbing should be tested for leaks before the house is occupied. This may be done by pouring into the highest point one ounce of *oil of peppermint* in a bucket of hot water. Another person who has not come into previous contact with the oil should inspect the respective floors after a lapse of ten minutes, when the leak will be discovered by the presence of the volatile oil. The man who handles the peppermint must remain on the spot until the investigation has been made below; it requires extreme caution, as a single drop emitted elsewhere will destroy the value of the test. Special glass grenades charged with the oil of peppermint or other pungent chemicals have been prepared for use of sanitary inspectors. The system may also be tested before the water-closets are connected by soldering over the apertures where the traps are connected with the soil pipes and then filling the pipes with water. This is a severe test, but very certain, as any subsidence in the level of the water indicates a leak which can be searched for as long as the "stack" of soil pipes and drain is exposed to view.

Sometimes the "smoke test" is applied from below; the smoke, being forced up the pipes by means of a small bellows or smoke rockets, will be emitted through the leaks and thus lead to the discovery of the defects. Of course all openings known to exist must first be closed and the smoke test should be connected with the lowest possible point. This test is not so reliable as the others named. It is desirable to test the plumbing system every year or two as settlement of the house often causes joints to open and lead bends to crack that would otherwise go unnoticed.

The *gas pipes* should also be tested before lathing and plastering is begun, otherwise great damage may be done. For this purpose all the outlets are capped except one, to which is attached a tube connected with an air pump and mercury gauge. Air is pumped into the whole system and the stopcock turned, and if after working the pump for some time and stopping it the gauge shows in the course of thirty minutes no signs of sinking, the pipes may be taken as in a safe condition; but if the mercury in the gauge falls, owing to the escape of air from the gas pipes, there is a leak somewhere, which may be discovered by pouring a little ether into the pipes near the gauge and recommencing pumping, while another person searches for the leak at the various joints or outlets. Very minute holes may be detected by lathering the pipes with soap and water and making use of the pipe and pump to create soap bubbles. Similar tests are applied after the gas fixtures have been connected, so as to detect the presence of defective joints and keys; in this instance every burner is turned off except one to which is attached a tube connected with the air pump and gauge.

Sewage Disposal for Villages and Isolated Houses.—When we consider the fact that over seventy per cent. of our population reside in rural districts and occupy homes without sewer connections, we see at once why wells and outhouses are often dangerous neighbors. Mr. Philbrick, of Boston, has described a system of sewage disposal by irrigation which must commend itself as safe and practicable for all small villages and isolated houses, where the land has sufficient slope to afford the requisite grade. The requisites for this system, as stated by him in Parkes' "Manual of Practical Hygiene," vol. ii., p. 484, are as follows:

"First, land adapted to grass nearly level or gently sloping at the rate of one-fourth of an acre for a single family, or an acre for a combination of eight to ten families, if provided with a constant water supply under pressure. If the water supply is limited to what may be pumped by hand one-half of the above area will be ample.

"Second, the highest part of the land devoted to this purpose should be at least five feet below the level of the top of the drain where it leaves the house.

"Third, the soil should be thoroughly underdrained, if not resting on a dry and porous subsoil by nature. Under-drains are often needed in clayey or retentive soils and should be laid at least four or five feet below the surface, at intervals of about twelve feet, with a free outfall.

"Fourth, the land should be graded, unless tolerably smooth beforehand, so as to avoid sudden inequalities. A surface that is adapted to smooth mowing by hand is good enough for this purpose.

"Fifth, the soil must be entirely free from roots of trees and shrubs. These would choke the pipes in a few weeks."

If house drainage is conducted directly into porous tiles laid under the surface, the fluid part will escape at every joint while the solid matter is apt to cling to the interior and gradually fill them, so as to render them practically useless, hence arrangements should be made to discharge the sewage by means of properly trapped and ventilated drains into a water-tight cesspool, where it will macerate and liquefy, and to discharge the contents periodically with such a rush as to fill the whole system of distributing pipes at once and brush away slight obstructions which may have been left by former discharges. This can be accomplished by providing a stopgate in the outlet pipe where it leaves the tank to be opened by hand when the tank is full and closed again when empty, or by providing a siphon or float to discharge the tank automatically whenever filled.

Mr. Philbrick has modified Field's siphon to be used in connection with these sewage tanks. One of the objections to this plan of subsoil irrigation, while excellent in principle, is the possibility of the roots entering the porous tiles and choking them; there is also danger from frost, and if laid deeper than one foot the vegetation cannot assimilate the very matter we wish to dispose of; for these reasons the writer favors the disposal by surface irrigation along the furrows of growing vegetation or in winter on the same garden spot.

Fig. 3289 shows such a method which Mr. Philbrick says has been in use for several summers at a house used only as a summer resort, and has been attended with complete success. There is an overflow pipe from the cesspool which is perfectly tight, indicating when it is full. The gate in the outlet pipe is then opened, and the whole contents are distributed on the kitchen garden in ten minutes. If an opportunity

is selected when the wind is blowing from the house to the garden, no offensive odors are perceived and the growing crops soon absorb the fluid, much to their advantage.

When a proper slope cannot be had, we must of necessity fall back upon either the earth closet, tonneau, or pail system for the collection of excreta, while the kitchen slops and refuse waters from the house should be conducted to some garden spot if practicable and disposed of by irrigation or carried into a dry well. The ordinary privy pits and open-box privies should never be tolerated; the undue prevalence of typhoid fever in rural districts is largely due to the use of these makeshifts and neglect in the disinfection of the excreta. The history of every sewered city shows a lessening of the typhoid death rate subsequent to the construction of the sewers and that the typhoid rate is always higher in sections supplied with privy pits and open receptacles. The only reasonable explanation for this is, that sewers carry away the filth and germs that otherwise would contaminate the soil and ground water. But even if there were no wells these makeshifts are still a source of danger, in so far as they favor the transmission of the infection by means of flies; nor can the possibility be ignored that the germs in leaky or overflowing boxes may reach the upper layer of the soil and with the pulverized dust gain access to the system. These conclusions were enunciated by the writer in 1895, and appear to have found ample support in the experience of the late Spanish-American war.

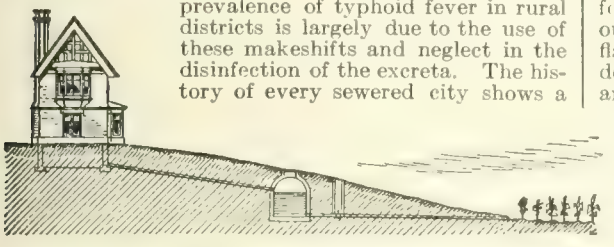


Fig. 3289.—Disposal of House Drainage by Surface Irrigation.

Miscellaneous Sanitary Requisites.—A consideration of modern house sanitation would scarcely be complete without reference to sanitary refrigerators lined either with glass or porcelain-enameled iron, provided with air circulation and trapped outlets. The waste water or drip pipe should not be connected directly with the soil pipe, but should drain into a sink or open fixture. The end of the drip pipe should be immersed in a cup of water to prevent bad odors or vermin from getting into the refrigerator, and it is needless to emphasize that refrigerators require frequent cleaning, which should be done as recommended for kitchen sink wastes. Fly screens for windows and doors are a necessity to prevent insect-borne diseases, but carelessness in their handling often renders them useless. The wire mesh should be sufficiently fine to exclude mosquitos, not less than fourteen meshes to the inch, and care should be exercised that no openings are left between the screens, windows, and doors to admit insects. Metal weather straps aid materially in keeping the cold air out in winter and in excluding much street dust. Lightning rods can scarcely be classed as a sanitary device, but they are a safety device and the recommendations of the U. S. Weather Bureau have done much to overcome the prejudice against their use. In isolated houses or in small communities where there is no public garbage collection, it may be fed to poultry or live stock, or used as a fertilizer or for fuel. For the latter purpose the fluids are first drained off and the refuse is then placed in a perforated receptacle and dried in a special, hot-air chamber connected with the lower part of the kitchen stove pipe. If economy need not be considered, a special "incinerator" or "destructor" can be installed.

House Diseases.—Special reference should be made to some of the insanitary factors likely to produce disease. Dampness of the basement and walls is certain to render the air of the house damp; this not only leads to undue abstraction of animal heat, but also influences the cutaneous functions and favors the development of microorganisms. The air of habitations may be vitiated not only by the products of respiration and by exhalations of the skin and mouth, but also by the products of combustion, by putrid gases from decomposition of organic matter (more especially sewer air), and last, but not least, by the household dust. Drs. Charles Smart and R. J. E. Scott in their able article on air, pp. 158–168, vol. i., have fully set forth the nature and effects of these impurities. Severe outbreaks of acute tonsillitis, marked by great inflammatory swelling of the tonsils, foul tongue, gastric derangement, severe headache, intense depression and high temperature, have been attributed by some authorities to the entrance of sewer polluted air into the habitations. Cases of typhoid fever, gastro-enteritis, diarrhea, and dysentery have been attributed to the same cause, and Parkes tells us that in general and lying-in hospitals in which the air of wards was liable to pollution from drains, surgical fever, erysipelas, pyemia, septicemia and puerperal fever were quite prevalent and fatal. Since sewers receive the excreta of patients suffering from intestinal infections and also the wash-water and secretions from persons and clothing of other infectious diseases, it may be presumed that they contain the carriers of many diseases, but it is not so easy to explain the liberation of microorganisms from the sewage. Some believe that there is always a possiblity of particles of sewage becoming dried and as particles of dust gaining access to the air, while others contend that during evaporation or from the bursting of bubbles of gas when the sewage is putrefying, the germs may be projected from the liquids into the sewer air, and may then in consequence of defective traps or joints in the drains be blown into the house. While there is ample room for speculation on the subject, in the present state of our knowledge we may conclude at least that whether sewer air contains specific organisms or not, its constant inhalation cannot fail to lower the power of the system to resist the invasion and effects of pathogenic germs, and that the emanations from choked house drains are more injurious than those from sewers. The inhalations of household dust, apart from the mechanical irritation of the mucous membranes produced thereby, may also be the means of carrying infection; since the tubercle and influenza bacilli and the pneumococcus are doubtless often conveyed from dried and pulverized sputum or mucus deposited in the room. When we recall the bad effects of deficient sunlight, of dampness, impure air, and excessive summer heat, we can appreciate why some of these factors should be especially potent in unsanitary dwellings in the production of certain typical house diseases.

Scrofula, or more correctly speaking a chronic form of tuberculosis of the glandular system, is especially common among children brought up in dark, gloomy, and damp habitations. These children are anemic and as puny as plants reared without the stimulating effects of sunlight. Add to this fact that dampness favors the development of catarrhal conditions which render the system more vulnerable to tuberculous infection, and we have a reasonable explanation why this disease, as well as *pulmonary tuberculosis*, prevails especially among inmates of damp and dark basements and back-to-back houses. The death rate is often double and treble that of other localities, and while there are doubtless other factors which determine this frightful mortality, none are more potent than deficient sunlight and ventilation, especially in view of the fact that the ubiquitous tubercle bacillus clinging to floors and walls in carelessly expectorated sputum, may retain its vitality and even proliferate in damp and badly lighted rooms. For similar reasons

diphtheria and *cerebrospinal meningitis* are also more frequent in unsanitary dwellings. *Acute* and *chronic rheumatism* and *bronchial affections* are likewise of more common occurrence in damp houses, and in recently constructed houses which have not been sufficiently dried and aired. Here again the continued abstraction of animal heat lowers the vitality of the inmates and favors the development of these affections and a bronchial catarrh thus produced may render the mucosa vulnerable to the invasion of the tubercle bacillus.

Infantile diarrhea is more frequent and fatal among the inmates of the upper stories; this is doubtless due to the enervating effects of heat and the more speedy decomposition of food, especially the milk, in the heated atmosphere; at all events, Meinert has shown that the mortality from cholera infantum, at Dresden, was 11.27 per cent. in the top stories as compared with 9.13 on the second and 3.98 on the first floors. Similar observations have been made at Berlin, which also developed the fact that still-births occur in a larger proportion among the occupants of the upper stories of houses. Whether this condition is due to the causes already mentioned, to sociological conditions, or to stair-climbing, remains to be determined.

Sanitary Inspection of Buildings.—The eradication of preventable diseases is the highest aim of scientific medicine, and the time may come when the public is willing to compensate the physician "to prevent by watchful foresight so far as is consistent with the progress of human knowledge" the outbreak and extension of such diseases. Indeed even now it is the duty of health officers and medical officers of the public services to examine into the cause of outbreaks of contagious and infectious diseases, and it is therefore desirable to point out some of the subjects to which an intelligent sanitary inspector pays special attention. Such an examination should include the character of the site and soil, the building plans, material and construction, ventilation, heating, lighting, plumbing, water supply, and the collection and disposal of refuse, and presupposes a knowledge of the causes of propagation and best methods of prevention of infectious diseases; also a knowledge of sanitary chemistry, microscopy, and bacteriology in order to determine the impurities in air, water, soil, food, etc., the prompt and accurate diagnosis of disease and the efficient use of disinfectants;—in fact, a good sanitary inspector must possess a general knowledge of the subject under discussion, good common sense, the habit of accurately observing facts, and the power for reasoning from causes to effects and by way of exclusion.

Before beginning the examination of a building or locality proper it will be well to gather all the information possible from all persons likely to throw light on the subject of bad water, offensive odors, and many other details, for, as remarked by Mr. Frederick N. Owen, "he will often find that this testimony will be uniform in a certain direction and will save him much time and labor in the investigation he is about to make, by directing his attention to some one point as the probable cause of the trouble." There are thousands of houses, clean and well-kept inside, which are steeped in the foul exhalations rising from cesspools and vaults in the immediate vicinity; if, therefore, offensive odors are noticed only when the wind is from certain directions, the inspector would do well to look for the nuisance in that direction. The inspector should be systematic in his methods and all the observed facts should be carefully noted in a memorandum book.

1. The examination of the site should include its relations to sources of soil, water, and air pollution, such as proximity to marshes, factories, and other nuisances, the presence of ponds and stagnant pools with special reference to mosquitos as carriers of malaria. Attention should be paid to the elevation of the site and its relation to adjoining lands as regards drainage; to the amount and duration of sunlight, prevailing winds, and the character and amount of dust; and to the influence of vines such as ivy, etc., on the walls, or of trees close to the house, in causing dampness by shutting off sunlight and air. The examination should also be directed to the cleanliness of the yards, outhouses, and the character of the diseases in the neighborhood. The writer in 1895 recorded a number of house epidemics of typhoid fever in which the infection was doubtless carried from privies to the food supply of neighboring houses by the agency of flies.

2. The examination of the soil on which the house stands, with special reference to dip of strata, porosity, and soil pollution, height and fluctuations of the ground water as determined by the water level in neighboring wells. A porous soil like sand, unless upheld by a stratum of clay, is usually dry and salubrious; clay and rock are impervious to moisture, and the water usually flows along the surface to some lower point; situations at the base of a hill are especially objectionable, as the ground water from higher levels generally comes here near the surface and renders the soil and air by capillary attraction and evaporation more moist than at any other point, and this dampness may extend to the walls of the house unless special precautions have been taken in the manner described on page 334 ("Construction of the House").

3. The examination of the plans, number of stories, construction and interior arrangement of the house should include the permeability and hygroscopic properties of the building material. Our general knowledge of the relative permeability of different kinds of building material will enable us to form an opinion, but for exact determinations the use of a poroskop, or gasometer and manometer becomes necessary. The capillary attraction may be determined by drying a suitable piece of the material, placing the lower end in water, and noting the height to which the moisture ascends. The effective humidity of certain building materials is determined by weighing a certain sample and after drying it at a temperature of 100° C. to weigh it again. The loss in weight indicates the amount of moisture. The relative capacity of certain building materials for parting with their moisture can be determined by placing two equal-sized pieces in water until completely saturated, and then, after wiping them off rapidly, exposing them to a uniform current of perfectly dry air. From the length of the time consumed in drying, the capacity for evaporating moisture may be calculated. The material, character, and condition of the roof, gutters, and rain leaders should receive careful attention.

4. The examination of the air in the interior is important. Here we should remember that whenever the volume of CO_2 amounts to seven volumes per 10,000, with a proportionate increase of organic impurities, a want of freshness is observed, and when nine or more volumes are present the organic odor becomes quite perceptible although, as pointed out by Dr. Smart (see *Air* in Vol. i.), the continued occupancy of an apartment may give rise to organic odors, clinging to the walls and other surfaces, when CO_2 may not be present in large quantity. Before entering into a systematic examination of the air for the determination of its impurities as regards carbonic acid, organic matter, ammonia, hydrogen sulphide, carbon monoxide, micro-organisms, and humidity, and for the determination of cubic air space for the occupants, it will be well to note the character and habits of the inmates as regards cleanliness, the amount of household dirt and dust which has accumulated on the walls, floors, and furniture, and to examine the closets, slop-pails, garbage, and ash receptacle, as well as the condition of the water-closets. The latter are often found

with no connection with the outer air, being located in the middle of the house. Most of the private dwellings have no other way of changing the air than through doorways, windows, transoms, and the seams of imperfect workmanship.

5. We should study the arrangement of rooms, their length, breadth and height, floor and cubic air space for each occupant, distribution of light, number of doors, transoms, and windows, sufficiency of ventilation, the size of fresh-air inlets and outlets, their cleanliness and freedom from obstructions. We should also test the humidity of the air in different stories by means of a reliable hygrometer, remembering that a humidity of 60°, saturation being 100, is the limit for healthy dwellings in this country. If the house is found to be noticeably damp, we may find the cause in imperfect cementing of cellars or basements, in the absence of damp-proof courses in the walls to prevent capillary attraction, in leaking down-spouts, house drains or water-pipes, in ash heaps piled against the wall, absorbing and retaining moisture, in obstructions to air and sunlight, etc.

6. The methods of heating, as by stoves, open fire-places, steam, hot water, or hot-air furnaces. If the house is heated by a furnace, the position of the fresh-air inlet with reference to sewer drains, underground ducts, and other impure sources should be noted. The very place which should be well cemented to exclude ground air—namely, right under the furnace—is frequently neglected. Basements and cellars must be cemented to exclude not only dampness but the equally objectionable ground air with its excess of CO_2 and other impurities. We should also note the character of fuel, the provision of dampers and presence of coal gas, the amount of heat obtained and the quality of the air.

7. The question of natural and artificial light should receive consideration, and the average amount and duration of sunshine should be noted. Thus, for example, the proportion of window to floor space should be one-sixth or one-fifth, and in temperate climates direct sunshine should reach, when practicable, all parts of the room. The sufficiency of artificial lighting may be approximately determined by observation, and quite accurately by the employment of Bunsen's photometer. In this country, the unit adopted for the measurement and comparison of lights is a No. 6 sperm candle, burning eight grams per hour and giving out a light known as "one-candle-power." Such a candle, according to Munson, contains, on analysis, carbon eighty per cent., hydrogen thirteen per cent., oxygen six per cent. The quality of the air and the temperature of the room lighted with ordinary illuminants should also receive attention.

8. The inspection of the plumbing is one of the most important features of a sanitary inspection. If an offensive odor is perceived in the basement it will suggest the possibility of a leaking drain pipe; and if inquiry reveals the frequent presence of rats, we may infer that the house drain is in direct communication with sewer and that the traps and lead bends are likely to be gnawed and leaky. Unfortunately, in most buildings the pipes are hidden behind woodwork and underneath floors, and the owner never appreciates the importance of exposed work until the workmen have to tear up floors and walls to permit of the necessary inspection and repairs. Of course this should not be done until a general examination and the tests for plumbing already referred to indicate defective work. Very often, too, the owner has not the faintest idea of the location of the house drains and soil pipes, and this suggests the necessity of a law compelling every householder to preserve a set of drawings showing the location of drains and vertical soil pipes.

The inspection of plumbing should begin with the main drain and proceed upward to all the ramifications, special attention being paid to imperfect caulking of joints, open connections, putty joints, holes plugged with corks, rag-patches, spots of corrosion, lead pipes gnawed open by rats, etc.

The fixtures should be carefully examined and their traps or water seals tested in order to learn their efficiency against the entrance of sewer air; this unsealing, unless special precautions have been taken, is sure to occur if the fixtures remain unused for a certain time and the water in the traps has evaporated. To make this test Mr Owen suggests that "all the basins, baths, and other fixtures above the traps to be tested and on the same line of piping should be filled with water and then discharged simultaneously, care being taken that all the pipes are free from obstruction. The fixtures below the trap should then be filled and discharged in the same way. If the trap retain its seal under these tests, it is safe to assume that it is an effectual barrier to the entrance of sewer air." For the detection of pin holes in the pipes, etc., which cannot be seen by the naked eye, the "peppermint," "smoke test," or some other pungent chemicals should be employed in the manner described on page 350.

The following list of defects in plumbing and drainage have been encountered by Mr Owen, and numerous specimens illustrating these defects have been observed by the writer in the Museum of Hygiene, in the City of Washington:

1. Earthen-pipe drains, either broken or with leaky joints, laid under the cellar floor, saturating earth with sewage. 2. Section of earthen pipe drains completely obstructed by the insinuation and growth of the roots of trees. 3. Pipe drains without sufficient grade or with the fall in the wrong direction. 4. Drains without running traps admitting sewer air from sewer or cesspools to the pipes in the house. 5. Drains without a free current of air. 6. Rat burrows from sewers and along drains undermining floors and admitting foul air to the house. 7. Section of soil pipe, the lumen of which was completely obstructed by urinary deposits, because of the exposure of the soil pipe on the outside walls of the house in cold climates. 8. Soil or waste pipes without any or sufficient ventilation. Defective connections between fixtures and waste pipes. 9. Lead pipes and traps gnawed by rats. 10. Water-closets, cistern with overflow joined to soil pipe or drain. 11. Safes under closets or basins connected to soil pipe or drain. 12. Two or more fixtures with unventilated traps on the same line of pipe, siphoning each other when used. 13. Sink overflow pipes joined to soil pipes untrapped or with trap liable to siphon. 14. Overflow from fixtures connected with waste pipe on sewer side of trap admitting foul gases to rooms. 15. Faulty traps and fixtures without traps. 16. Water supplies to sinks taken from water-closet or other contaminated tanks and used for drinking purposes. 17. Rain leaders used as soil pipes or ventilators to drains, delivering foul air to bedroom windows or under eaves or roofs. 18. Ash pits near larders and pantries, or liable to soak moisture to walls. 19. Defect of drainage and rat burrows from neighboring houses, especially from those located on a higher level. 20. Cesspools near houses, wells, or cisterns, polluting the drinking-water.

If an outbreak of contagious or infectious disease is being studied, and up to this point the inspector has not reached any conclusion, it is desirable to consider the possibility of the germs being carried by flies, mosquitos, and other insects. Our investigation should, of course, extend to the water supply, milk, food, and even the ice supply.

The general principles set forth in the foregoing pages are equally applicable to the inspection of public buildings, schools, hospitals, prisons, barracks, asylums, etc. (For inspection of dairies, etc., see *Milk-Borne Diseases.*) GEORGE M. KOBER.

Hufeland, Christoph Wilhelm.—Born at Langensalza, Germany, August 12, 1762. He began the study of medicine in 1780 at the University of Jena. In 1781 he went to Goettingen, and in 1783 received from that university the degree of Doctor of Medicine. Ten years later (1793) he was called to fill the Chair of Medicine at Jena, and at the same time the dignities of Court Physician and Councillor at Weimar, the capital of the Grand-Duchy of Saxe-Weimar-Eisenach, were conferred upon him. In 1798 he

Fig. 3290.—Christoph Wilhelm Hufeland.

removed to Berlin and was made the head of the medical college in that city. After the founding of the University of Berlin in 1809 he was chosen Professor of Pathology and Therapeutics in that institution. His death occurred August 25, 1836.

Hufeland's "Art of Prolonging Human Life" (Makrobiotik, oder die Kunst, das menschliche Leben zu verlängern), which was published in 1796 and was translated into many languages, made him famous all over the world. The book is full of ideas and instruction of a thoroughly practical nature. Another of his published writings is that entitled: "System der praktischen Heilkunde" (1818–1828), said to be the most elaborate of all his works. A. H. B.

Huguier, Pierre Charles.—Born at Sézanne, France, in 1804. He was appointed an interne in the hospitals of Paris in 1828, and in 1830 he won the prize, a gold medal, offered by the hospitals, which enabled him to remain two years longer. During this same year he became Assistant in Anatomy in the Faculty of the University of Paris. He received his medical degree in 1834, and in 1837 was appointed surgeon to the hospitals. In 1848 he was made a member of the Academy of Medicine. He was one of the founders and one time president of the Surgical Society of Paris, and an officer of the Legion of Honor. In 1863 he received the professorship of the Chair of Anatomy in the École des Beaux-Arts, which appointment he held until his death on January 12, 1873.

Huguier became a well-known gynecologist of Paris, and was about the first to differentiate between hypertrophic elongation of the cervix uteri and prolapsus uteri, offering as a remedy amputation of the neck of the uterus. This operation he performed most successfully. He also made a clear, scientific study of the glands in the vaginal region. "Huguier's canal," a canal in the temporal bone which transmits the chorda tympani nerve, was discovered by him.

The following are among the most important of his writings: Sur l'existence du virus syphilitique, 1831; Mémoire sur le diagnostic, 1833; Syphilis des Traitement des constrictions de l'extrémité inferieure du vagin, 1834; Syphilis des femmes encientes et des enfants, 1840; Maladies de la glande vulvovaginale et des divers appareils sécréteurs, 1850; Ankyloses du maxillaire inférieur; Operation de la hernie etranglée; Operations sur l'organe de la vision.

A. H. B.

Humboldt Artesian Mineral Spring.—

Post-office.—Eureka, California.

The water of this mineral spring, or rather artesian well, is an article of commerce, and is called Humboldt Mineral Water. The following analysis is given:

Sodium chloride	32.91
Calcium carbonate	15.37
Magnesium	10.63
Sodium	2.45
Silica	1.32
Alumina	0.20
Iron oxide	0.06

The spring is within the city limits of Eureka, about a quarter of a mile from the street car line.

Emma E. Walker.

Humulus.—Hops. The carefully dried strobiles of *Humulus lupulus* L. (fam. *Moraceæ* [*"Urticaceæ,"* U. S. P.]), bearing the whole of their natural glandular coating. The hop vine is a twining perennial, with a thick-branched root, from which several long, slender, herbaceous, but tough and rough hairy cylindrical stems arise.

Fig. 3291.—Hop Plant in Fruit. (Baillon.)

The hop is a native of the temperate parts of the Old World—Europe and Asia—and grows in many places in the United States apparently wild, but probably introduced. It has been cultivated since the middle ages in Europe, and is now grown in nearly all temperate countries. England and the United States produce it abundantly, and of excellent quality.

Description.—Ovoid-cylindrical, about three centimeters (a little more than an inch) long, consisting of a thin, hairy, flexuous rachis and many obliquely ovate, blunt, membranaceous, rigid, glandular scales, which

are parallel-veined below, reticulately veined above and each bearing a globoidal akene near the base; color of scales yellowish-green to greenish pale-brown, free from reddish or brown spots; odor strongly and peculiarly aromatic; taste bitter, pungently aromatic, slightly astringent.

Since the glandular coating (*Lupulin*) referred to in the definition contains the most of the active constituents, it should be present in normal amount, but much of the hops of the market have been deprived of a part of it by abrasion. Such hops are apt to be much broken, and are commonly pressed into cakes to conceal this appearance.

Good hops should be not much broken, and fresh. They are then of a rich, slightly yellowish or brownish green. When distinctly brown and dull, and especially shrivelled, they are stale and their composition is not the same.

The medicinal consumption of hops is comparatively small, and an unimportant item of the immense demand for them, mainly for flavoring ales and beers, which consumes many millions of pounds annually.

Composition.—The entire hop, that is, inclusive of the *lupulin*, contains the following substances: Nearly one per cent. of volatile oil, of a greenish-yellow color,

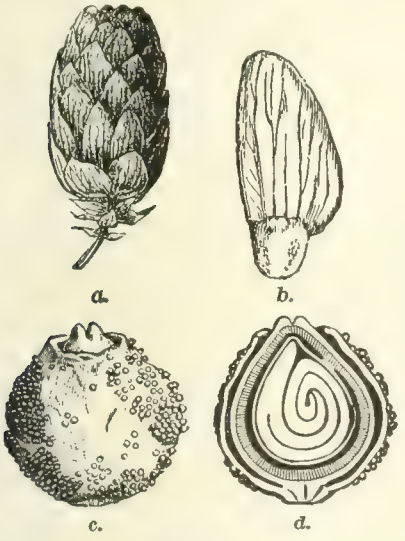


Fig. 3292.—Hop Plant. *a*, Cone; *b*, fructiferous bracelet; *c* fruit enlarged; *d*, the same in longitudinal section.

becoming brownish with age, and of a specific gravity of 0.855 to 0.880. It becomes at least partly converted into isovaleric acid. A very small amount of the intensely bitter *lupamaric acid* ($C_{25}H_{35}O_4$), which is soluble in alcohol or a mixture of alcohol and water. Resin, up to fifteen or eighteen per cent.; tannin two to four per cent. Small amounts of asparagin and cholin. Not more than ten per cent. of ash is allowable upon incineration. According to their staleness, more or less *phlobaphene* may be present, at the expense of the disappearing tannin.

Action and Use.—Although used in many diseases with asserted benefit, but little can be said of hops more than that they are a mild bitter tonic and (especially lupulin) a feeble hypnotic and antispasmodic. In infusion they allay the pain and spasm of vesical catarrh, and improve the appetite and digestion. As an ingredient of beers they add a tonic, and perhaps diuretic, effect to that of the alcohol in those beverages. The dose is gr. xv.–lx. (1.0–4.0). The Pharmacopœia provides, besides lupulin (*q.v.*) and its preparations, a twenty per cent. tincture, the dose of which is fl ʒ i.–ij. (4.0–8.0), and which is probably the best form of administration.

Henry H. Rusby.

Hunter, John.—Born February 13, 1728, at Long Calderwood, Lanarkshire, England. He was the youngest of ten children, and, partly for this reason and partly because he was very fond of country amusements and averse to restraints of all kinds, he received little or no school training. At the age of twenty he asked permission of his brother William, who was conducting at that time the most celebrated anatomical school in London, to aid in making dissections. His request was granted and he was set to work dissecting the muscles of an arm. He did the work to his brother's satisfaction. Then William gave him the more difficult task of dissecting similar

Fig. 3293.—John Hunter.

parts in a cadaver the blood-vessels of which had been injected; and here again the dissection was so well performed that William predicted that his brother would become a good anatomist. From this time onward the latter advanced so rapidly in his acquisition of anatomical knowledge that already during the following year it was decided that he might be entrusted with the charge of his brother's practical class. In 1749–1750, he attended the lectures and operations of William Cheselden at the Chelsea Military Hospital; in 1751, he became a surgeon's pupil at St. Bartholomew's Hospital; in 1754, he occupied the same position in St. George's Hospital; and in 1756 he was appointed House-Surgeon in the latter institution. In 1759, symptoms of pulmonary tuberculosis having manifested themselves, he applied for and obtained (in 1760) the appointment of staff-surgeon in Hodgson and Keppel's expedition to Belle-Ile-en-Mer, off the coast of Brittany. In 1762, he served with the English forces on the frontier of Portugal. Upon his return to England in 1763 he took a house in London and began the career of a practising surgeon. All through this early period of his professional life (1748–1763) John Hunter was constantly carrying on investigations of one kind or another in human and comparative anatomy, in physiology, in embryology, in surgical pathology, etc.; and he continued making such investigations, but with still greater zeal, during the remainder of his life. In many of these researches his chief object was to throw additional light upon certain surgical procedures or upon certain pathological phenomena observed by him in the course of his surgical practice; in short, a large part of this work, which apparently was of a purely scientific character, had a thoroughly practical purpose.

In 1786, Hunter became Deputy Surgeon-General to the Army, and in 1790 he was appointed Surgeon-General to the Army, as well as Inspector-General of

Hospitals. After the death of Pott, in December, 1788, Hunter was universally admitted to be the first surgeon in England. His death occurred October 16, 1793. His remains rest in Westminster Abbey.

Of John Hunter's published writings that entitled "A Treatise on the Blood, Inflammation, and Gunshot Wounds" is undoubtedly his masterpiece. The application of physiology to practice is especially noticeable in this treatise. To his museum Hunter gave a very large share of his attention. It is to-day housed in a suitable building in Portugal Street, London, under the care of the Royal College of Surgeons. A. H. B.

Hunter, William.—Born at East Kilbride, Lanarkshire, England, May 23, 1718. He was an elder brother of John Hunter. At the age of fourteen he was sent to the University of Glasgow, where he studied for five years. On the advice of Dr. William Cullen he resolved to devote himself to physic. From 1737 to 1740 he resided with Cullen at Hamilton, and then spent the winter of 1740–1741 at Edinburgh. From this city he went to London and entered as a surgeon's pupil at St. George's Hospital. He also

Fig. 3294.—William Hunter.

received instruction in anatomy from Frank Nicholls. In 1746 he undertook the delivery, for a society of naval practitioners, of a series of lectures on operative surgery; and these proved so satisfactory that he was requested to include anatomy in his course. In 1748, having renounced surgical for obstetric practice, in which he excelled, he was appointed a Surgeon-Accoucheur at the Middlesex Hospital, and in 1749 at the British Lying-in Hospital. The degree of M. D. was conferred upon him by the University of Glasgow in 1750. In 1762 he was made Physician Extraordinary to her Majesty, Queen Charlotte. He died March 30, 1783.

Hunter's great work, "The Anatomy of the Gravid Uterus, exhibited in Figures," was published in 1774. A. H. B.

Hunter's Hot Springs.—Park County, Montana.

Post-office.—Springdale. Hotels and sanatorium.

Access.—Viâ Northern Pacific Railroad to Springdale, where autostages connect with the springs, two miles distant, the road crossing a magnificent iron bridge on the Yellowstone River. Hunters' Springs are situated at the base of the foothills of what is known as the Crazy Range of mountains. The location is 1,000 miles west of St. Paul and 920 miles east of Portland, Oregon, and has an altitude of 4,480 feet above the sea level. The surrounding scenery is of the grand and romantic character commonly found in the Rocky Mountains. The climate is dry and salubrious, and severe storms are unknown. The thermometer seldom reaches as high as 98° F. in summer or as low as zero in winter. The springs boil up from a rocky ledge in the bottom of a little valley or basin inclosed by gently undulating hills. They are twenty-seven in number and are arranged in three principal groups, varying in heat from 148° F. to 168° F., with a combined outpour of about 90,000 gallons per hour. The water is clear and sparkling and remarkably soft. The baths for women and men are in separate departments, each fitted with a plunge, tub, and vapor baths, and heated by the hot waters. About eighty rods from the bath-house is an outdoor summer bath, about one hundred and five feet square and from four to six feet deep, supplied with water from the lower group. This is said to be the largest bath of hot mineral water in the United States. The sanatorium connected with the springs has recently been enlarged and is adequately prepared for the reception of various classes of patients.

The springs are known as the Upper, Lower, and Hidden Springs. The Upper and Lower Springs are each protected by picturesque kiosks, or spring-houses, for the shelter of those who come to drink the waters. The following is the analysis of the water of the Upper Spring, temperature 148° F. made by Prof. W. M. Cobleigh, of the Montana State College of Agriculture and Mechanic Arts.

Hypothetical form of combination:

	Pts. per million.	Grains per U. S. gallon.
Ammonium chloride	0.713	0.04
Lithium chloride	0.36	0.02
Potassium chloride	1.5	0.09
Sodium sulphate	10.8	0.62
Sodium metaborate	Trace	Trace
Potassium sulphate	0.4	0.02
Sodium carbonate	60.4	3.52
Sodium bicarbonate	208.8	12.17
Magnesium bicarbonate	1.9	0.11
Disodium arsenate	Trace	Trace
Calcium silicate	5.2	0.30
Alumina	0.6	0.03
Silica	60.2	3.50
Hydrogen sulphide	5.50	0.32
Total	356.373	20.74

According to Peale's classification of mineral waters, this is a thermal, sodic carbonated, and bicarbonated alkaline lithic sulphureted water.

While the waters at Hunter's are delightful for baths alone, it is their medicinal value that renders them specially desirable and valuable. They are very useful in the treatment of rheumatism, gout, asthma, catarrhal conditions of the pharynx, larynx, and bronchi, diseases of the kidneys, liver, stomach, nerves and skin, uterine diseases, chronic metallic poisoning, and syphilis. There are two hotels at Hunter's. The new hotel is modern in all of its appointments, capable of accommodating 300 guests. An independent water system provides good fire protection. There is a large and very fine plunge, or swimming pool, 100 by 50 feet in size with all modern accessories, including a gymnasium. Hard by the baths is the solarium of sixty feet radius. The cuisine is excellent, the table being largely supplied by the hotel's farm and ranch. There is a fine golf course. And the region about the springs is a famous hunting and fishing resort. Emma E. Walker.

Hunyadi Janos.—A mineral spring at Ofen, Hungary, a part of Budapest. The active ingredients are the sulphates of sodium and magnesium. The follow-

ing table shows the proportions in which they occur in the various Hungarian waters.

	One Liter of Water Contains	
	Sodium sulphate Grams.	Magnesium sulphate Grams.
Hunyadi Janos	22.55	22.35
Franz-Josef	23.18	24.78
Apenta	15.40	24.40
Puellna ..	9.59	10.85
Friedrichshall . . .	6.05	5.15
Kissingen Bitterquelle.	5.80	5.00

The following is an analysis of the Hunyadi Janos water by Professor Bunsen. One pint contains: Sodium carbonate, gr. 13.20; ferrous (oxide) carbonate, gr. 0.08; calcium carbonate, gr. 6.04; strontium carbonate, gr. 0.19; sodium chloride, gr. 11.54; potassium sulphate, gr. 1.67; sodium sulphate, gr. 128.97; magnesium sulphate, gr. 137.98; silicious earth, gr. 0.09. Total, 299.76 grains. Free and partly combined carbonic acid, 8.06 cubic inches.

Other well-known waters of like character are those of the Rubinat Condal, Rubinat Serre, and Rubinat Llorach Springs in Spain.

The taste of these waters is disagreeably bitter, much like a solution of "Epsom salts," although it is said to be somewhat modified by the presence of free carbonic acid and the other salts; at best, however, they are not a pleasant drink.

These sulphated bitter waters are much employed either as an occasional aperient, or in habitual constipation and in dyspepsia accompanied by constipation. They are also a serviceable laxative in small doses in pregnancy, arteriosclerosis, cardiac disease, and other morbid conditions in which an unstimulating laxative is desired. In large doses they are indicated where a rapid, full evacuation of the bowels is the end in view. In brief, in all the innumerable conditions in which a "dose of salts" is indicated, these bitter waters, which are practically a solution of salts, can be used. The usual dose of the strong bitter waters is from a half to one wineglassful taken on an empty stomach. In emergency cases a larger dose can be taken—from three-quarters to one tumblerful. Edward O. Otis.

Huschke, Emil H.—Born at Weimar, Germany, December 14, 1797. He received his preliminary education in his native city, but studied medicine in Jena, under Oken, and obtained his degree in 1818. Later he went to Paris to study, returning to Jena, however, to establish a practice. In 1824 he was made Professor Extraordinary, and in 1827, upon the death of Loder, he received the appointment of Professor of Anatomy in the University of Jena, which he held until his death on June 19, 1858.

Huschke became a well-known anatomist and embryologist, and contributed much to the knowledge of these subjects through his discoveries, the chief of which are: The development of the thyroid gland; the invagination of the crystalline lens; the so-called "Huschke's teeth" in the cochlea, and a cartilage in the nose; a crystalline form of otoliths; "Huschke's foramen" a perforation found in the tympanal plate due to arrest of development; "Huschke's ligament," a peritoneal fold found on the upper portion of the smaller curvature of the stomach and extending to the anterior surface of the pancreas, also "Huschke's valve," plica lacrimalis.

His writings are the following: "De embryologia hominis," 1820; "Eingeweidelehre und Sinnesorgane," 1844; "Ueber die Umbildung des Darmcanales und der Kiemen bei den Froschquappen," 1825; "Ueber die Kiemenbogen und die Kiemengefässe beim bebrüteten Hühnchen," 1828; "Programma de pulmonum quadruplicitate," 1823; "Ueber die Textur der Nieren," 1828; "Ueber die Sinne," 1824; "Craniosklerosis totalis rhachitica," 1858. E. L. J.

Hutchinson, Sir Jonathan.—Born at Selby, Yorkshire, England, July 23, 1828. He received his early education at his native town and was then apprenticed, in accordance with the custom of the day, to a practitioner in York, Mr. Caleb Williams, who lectured on materia medica and therapeutics at the York School of Medicine. In 1847 he entered St. Bartholomew's Hospital and qualified in 1850 in the usual manner by taking the Membership of the Royal College of Surgeons of England and the License of the Society of Apothecaries of London.

Fig. 3295 Sir Jonathan Hutchinson.

Shortly after this he was appointed assistant physician to the City of London Hospital for Diseases of the Chest, and later surgeon to the Metropolitan Free Hospital, to the Royal London Ophthalmic Hospital, and to the Blackfriar Hospital for Diseases of the Skin. In 1859 he was appointed surgeon to the London Hospital, and from 1862 was lecturer on surgery in the Medical College, taking the additional subject of ophthalmology the following year. In 1873 he became senior surgeon, and in 1883 retired from active work on the hospital staff. From 1879 to 1883 he was Hunterian Professor of Surgery and Pathology at the Royal College of Surgeons. He served on the Royal Commission appointed in 1881 to inquire into the condition of the London hospitals for smallpox and fever cases, and into the means of preventing the spread of infection, and later on the Royal Commission on Vaccination (1890–96). In 1882 he was elected Fellow of the Royal Society, and in 1908 received the honor of knighthood for his distinguished services to medicine. He received honorary degrees from the universities of Glasgow (1887), Cambridge (1890), Edinburgh, Oxford, Dublin, and Leeds. He was a corresponding member of the Surgical Society of Paris, and an honorary member of many other European and American societies. He died at Haslemere, June 23, 1913.

While a stranger to no branch of medical knowledge, Hutchinson was especially famous as a surgeon, dermatologist, ophthalmologist, and syphilographer. He was also an earnest teacher and advocate of post-graduate study and was an enthusiastic believer in the value of objective teaching by means of museum collections. He established a medical museum first in his own house, where he gave lectures at certain times to all medical men who chose to attend, and later transferred the collection to the London Polyclinic which he and others had established. He also founded local museums for the study of natural history

at Haslemere, where was his country home, and at Selby, his birthplace. To a number of conditions and symptoms which he observed and first described his name has been permanently attached. For example, the facial expression of ophthalmoplegia is known as Hutchinson's facies, the mask-like appearance in tabes dorsalis as Hutchinson's mask, the unequal size of the pupils in meningeal hemorrhage as Hutchinson's pupils, the notching of the teeth in hereditary syphilis as Hutchinson's teeth, while the combination of interstitial keratitis, labyrinthine disease, and notched teeth has received the name of Hutchinson's triad.

For many years he was an energetic advocate of the theory of the influence of diet in the causation of leprosy. He did not deny the influence of contagion, but maintained to the end of his life that the leprous soil was prepared by the eating of long kept or partly decomposed fish, and he even traveled to India and South Africa to find material to support this theory.

Hutchinson was a voluminous writer. He always kept full notes of his cases and for ten years published the most interesting of them, with comments, in the "Archives of Surgery," a quarterly of which he was both publisher and editor, and to which he was the sole contributor. He wrote a manual on Syphilis and contributed the articles on Constitutional Syphilis in Reynold's "System of Medicine," on Hereditary Syphilis in the "Twentieth Century Practice of Medicine," on the Surgical Diseases of Women in Holmes's "System of Surgery," and on Syphiloderma and Drug Eruptions in Allbutt and Rolleston's "System of Medicine." He also published in 1863 "A Clinical Memoir on Certain Diseases of the Eye and Ear consequent on Inherited Syphilis," in 1884 a work on "The Pedigree of Disease," and in 1906 one on "Leprosy and Fish-eating." T. L. S.

Huxham, John.—Born in Devonshire, England, in 1692. He studied medicine in Leyden under Boerhaave, and later in Rheims, and on returning to England established himself in practice in Plymouth. Here he soon acquired fame and a large practice. He was elected a Fellow of the Royal Society in 1739, and in 1755 was awarded the Copley medal for an essay entitled "Medical and Chymical Observations upon Antimony." He made a special study of

Fig. 3290.—John Huxham

epidemic diseases and of their supposed relation to meteorological conditions, publishing a work on the subject, entitled "Observationes de aëre et morbis epidemicis." His two best known works are an "Essay on Fevers," London, 1739–1769, in which he advocated the use of the compound tincture of cinchona, thereafter known as Huxham's tincture; and "Dissertation on the Malignant Ulcerous Sore-throat," London, 1750–1757, in which he first gave an accurate description of diphtheria. Huxham died August 12, 1768. T. L. S.

Huxley, Thomas Henry.—Born at Ealing, Middlesex, England, May 4, 1825. He studied medicine at the Charing Cross Hospital, London. In 1845 he published, at the suggestion of his instructor, Wharton Jones, his first scientific paper, demonstrating the existence of a hitherto unrecognized layer in the inner sheath of hairs, a layer that has been known since as "Huxley's layer." In December, 1846, having taken service in the British Navy, he left England as surgeon to the "Rattlesnake," a vessel which had been despatched for surveying work in Torres Strait, to the north of Australia. He returned to England in November, 1850. During this voyage Huxley "gathered a magnificent harvest in the almost unreaped field (tropical marine surface-life), and the conclusions he drew from it were the beginning of the revolution in zoological science which he lived to see." (*Encyclo. Brit.*) From this time forward, if he had continued to retain the position of surgeon in the Navy, he would have been obliged to perform all the prescribed duties of the office; and this was certainly not the kind of work for which Huxley was fitted. He therefore resigned from the Navy, and gave himself up wholly to those biological studies which were soon to make his name famous throughout the world of science. The story of this remarkable career is well told in the "Life and Letters of Thomas Henry Huxley," by his son Leonard Huxley (2 vols., 1900). A. H. B.

Hyalin.—This is the chief organic constituent of the walls of hydatid cysts, and is related chemically to chitin. The walls of the older transparent cysts are composed of pure ash-free hyalin; thoes of the younger cloudy cysts are albuminous and contain various salts. Hyalin has been found only in echinococcus cysts. From the older cysts walls it is obtained in water solution under high pressure. This body should not be confused with pathological hyalin or hyalin degeneration. The latter does not represent a definite chemical entity but is applied to a variety of albuminous substances that are transparent, homogeneous and structureless, and do not give the specific amyloid reactions.

Pure hyalin is opalescent, transparent, insoluble in cold water, alcohol, and ether, but soluble in overheated water (150° C.). It is not soluble in acetic acid, and only slightly in cold hydrochloric and nitric acids, but dissolves completely in hot solutions of the latter two. In concentrated potassium and sodium hydroxides it is slowly and incompletely dissolved. According to Lücke its composition is as follows: C. 44.1–45.3, H. 6.5–6.7, N. 4.5–5.2, O. 43–44.7 per cent. From the water solution it is precipitated by alcohol, acetate of lead, and mercuric nitrate, but not by acetic acid and potassium ferrocyanide or mercuric chloride. By the latter reactions it is distinguished from albumin. Neither tannic acid nor chlorine water precipitates it. If the water solution is boiled with dilute sulphuric acid reducing substances are formed, which with yeast yield alcohol and carbonic acid, and are strongly dextrorotatory, proving to be grape-sugar It has been estimated that the older cyst walls yield fifty per cent. of their weight of this substance. From chitin, to which it is most closely related, hyalin is distinguished by its solubility in water at 150° C. Aldred Scott Warthin.

Hyaline Degeneration.—Under this head there is classed by various writers a large nunber of pathological processes of widely differing origin and nature, characterized in common by the production of a clear, homogeneous, refractive material to which the name hyalin is applied. The most comprehensive use of this term is that employed by von Recklinghausen who defines hyalin as a homogeneous, re-

fractive, albuminous body, staining well with eosin, carmine, picrocarmine, and acid fuchsin, resistant to water, alcohol, acids, and ammonia; in these respects resembling amyloid, but giving none of the specific amyloid reactions with iodine or the aniline stains. In accordance with this definition, he classes as hyaline substances epithelial colloid and keratohyalin (*epithelial hyalin*), the hyaline products of connective-tissue cells and intercellular substance (*connective-tissue or conjunctival hyalin*), hyaline products of coagulation (*blood hyalin*), hyaline inflammatory exudations on surfaces, into tissues, urinary tubules, etc. (*exudation hyalin*), and tissue necroses presenting a hyaline appearance (*hyaline necrosis*). Further, the hyalin formed in connective tissues is to be divided into two classes: that formed by a secretory process on the part of the connective-tissue cells, and that resulting from a degeneration or infiltration of the interstitial substance. Since these various substances are of different origin and are not chemically identical, as shown by their great difference in staining, the above classification, resting as it does only upon a common physical property, has not been accepted by the majority of pathologists, who class the greater part of these processes under other heads than that of hyalin, and restrict the term hyaline degeneration almost entirely to *epithelial hyalin* (colloid) and to the *hyaline changes occurring in connective tissue.*

Epithelial Hyalin.—(See *Colloid.*)

Hyaline Degeneration of Connective Tissue.—The group of changes occurring in connective tissue, in which the fibrous basic substance becomes structureless and homogeneous, is at the present time usually understood by pathologists when the term hyaline degeneration is used. In the earlier stages of this degeneration the connective-tissue fibrillæ become swollen and are gradually transformed into coarse, irregular hyaline strands or even into nodular masses; in other cases they may become confluent, forming uniformly homogeneous masses; or masses of hyaline substance may be formed between the fibrillæ, the latter gradually disappearing. Neither the hyaline material into which connective tissue may be transformed nor that by which it may be replaced has yet been shown to be a distinct chemical entity. In both cases the substance closely resembles amyloid, but differs from it in that it has no specific reactions with iodine and the aniline dyes. There are, however, reasons for believing that the chemical relationship of these substances is very close, inasmuch as it has been shown that the two are frequently found in combination and that under certain conditions amyloid may lose its specific reactions and become changed into hyalin. The formation of hyalin, similar to that of amyloid, in many cases partakes more of the nature of a *deposit* than a *true degeneration.*

The most characteristic staining reaction of connective-tissue hyalin is with acid fuchsin. This is best brought out by the methods of Van Gieson and Pianese. By means of this reaction it may be distinguished from amyloid, colloid, mucin, though its behavior with this stain is not always constant. The staining variations are, however, largely dependent upon the age and density of the hyaline substance, and the ease with which it is penetrated by the staining fluid. Recently formed hyalin stains light rose-red; old hyalin a very deep red when penetrated by the stain, but with Van Gieson's method it often stains yellowish, the acid fuchsin not having penetrated. It is very probable, however, that the hyaline changes in connective tissue are not identical, but represent a class of closely related conditions.

As in the case of amyloid, connective-tissue hyalin is most frequently found in the walls of blood-vessels, but differs from the former in being found in connective tissue without showing any relation to the vessels, particularly in the case of glandular stroma. Physiological hyalin occurs in large masses in ovarian corpora fibrosa, where it constitutes a normal formation in the process of obliteration of the corpus luteum. The formation of hyalin in the blood-vessels in old age is also to be regarded as of the nature of a physiological process. Under normal conditions the blood-vessels of the ovary are the first to show this change, and this organ at the menopause shows extensive hyaline change in the walls of its arterioles. A similar change is found at this time in the uterine vessels.

The pathological formation of hyalin may occur in apparently normal connective-tissue, or in that altered by pathological processes, in newly formed connective tissue following inflammatory processes or that developing in tumors. Hyaline degeneration occurs most frequently in the walls of the blood-vessels, heart valves, endocardium, kidney glomeruli, lymph glands, splenic follicles, connective tissue of the thyroid, parotid, lacrymal and mammary glands, tunics of the testis, periosteum, bursae and tendon sheaths. In the connective tissue of tumors it is of very frequent occurrence, particularly in the case of the endotheliomata of the serous glands and meninges. The reticulum of tubercles is often hyaline in character, and hyaline connective tissue is not infrequently formed about old tubercles, in old scars, granulomata, etc.

Hyaline change is rarely massive enough to be visible to the naked eye. When present to such an extent it is manifested by whitish, semitranslucent, hard and dense areas resembling scar tissue, replacing the normal structure. It is usually whiter and less translucent than amyloid. In blood-vessels showing much change the walls may be thickened, stiffened, and the lumen partially or wholly blocked. From the hard and dense character of the process hyaline degeneration is usually spoken of as sclerosis; in blood-vessels, either arterio- or phlebosclerosis.

Sclerosis of veins is not nearly so common as that of arteries, but is of quite constant occurrence in organs and tissues affected by chronic inflammatory processes. The sclerosis of arteries may be considered pathological when it occurs at an early age or to an excessive degree. The small arterioles of the splenic follicles, kidney glomeruli, brain and spinal cord, and the intima of the larger arteries are particularly subject to hyaline change. In many cases the hyaline substance is formed immediately beneath the endothelium in a manner similar to that of amyloid; in other cases there is first a proliferation of connective tissue beneath the endothelium, the new tissue gradually losing its nuclei and becoming converted into hyalin. Not infrequently the formation of hyalin takes place only in the outer coat of the vessel. The small arterioles of the splenic follicles and the kidney glomeruli are often the first vessels in the body to show sclerotic change. The extent and location of this change are, however, very variable; in some cases it may be confined to the coronary arteries, while in others the small arterioles of the central nervous system may alone be affected.

The connective tissue of fibromyomata very often undergoes hyaline change. Similar processes occur in the endothelial tumors of the brain, meninges, and serous glands. In these tumors the chief part of the growth may sometimes consist of hyaline material. When formed into cylinders or columns about the vessels the tumor is designed a cylindroma. In the mixed endothelial tumors of the serous glands hyaline material is formed after the manner of a secretion on the part of the endothelial cells lining the lymph spaces. A similar formation of hyalin at the expense of the interstitial cells occurs in the connective tissue of the conjunctiva and thyroid. In the latter the formation of hyalin in large amounts causes atrophy and compression of the glandular elements, so that not

infrequently there is left little functionating gland structure left, the entire organ becoming changed into a hyaline mass in which the glandular remains are with difficulty made out. The basement membrane of Bowman's capsule and of the acini of the mammary gland, as well as that of the tubules of kidney and testis under certain conditions, becomes hyaline. Atrophy of the parenchyma usually follows this change. Hyaline glomerular scars (obliterated glomeruli) are almost constantly found in the kidneys as the result of the destruction of the glomerular parenchyma; a similar sclerosis of the areas of Langerhans in the pancreas may occur in association with advanced general arteriosclerosis.

Fibrinous exudates upon serous membranes may become organized and the newly formed connective tissue suffer hyaline change. Such hyaline formations are not infrequently seen upon the surface of the spleen, liver, pericardium (so-called soldier or milk spots), and pleura. Old pleuritic and pericardial adhesions may be entirely composed of hyaline material, all cells having disappeared. The hyaline bodies called rice bodies or corpuscula oryzoidea found in pathological conditions of the tendon sheaths and bursæ are for the greater part composed of loosened masses of organized fibrin which have undergone hyaline change. In cirrhosis of the liver and in chronic nephritis the new connective tissue frequently is hyaline in character. Old infarct scars show a like change. After complete organization of obturating thrombi, blood-vessels may become replaced by hyaline cords. Similarly in chronic obliterative appendicitis the appendix may become changed into a hyaline cylinder in which even all traces of the muscle coats may have disappeared.

In lymphatic glands large masses of hyalin are frequently found, particularly in the atrophic glands of old age, or in association with chronic inflammatory processes. Here the change seems to be more of the nature of a deposit or infiltration. Large deposits of hyalin occur also in the hemolymph glands. Rarely, a progressive hyaline degeneration of many organs occurs—heart, vessels, serous membranes, spleen, lymph glands, intestinal wall, etc.—involving these either simultaneously or one after the other. In these cases portions of the hyaline substance may give an amyloid reaction. From this it may be inferred that there is a form of hyaline degeneration which is closely related to amyloid.

Of the nature of connective-tissue hyalin practically nothing is known. The disappearance of the nuclei, the subsequent retrograde changes in the hyaline substance, and its sequestration from normal tissue stamp the process as being essentially degenerative in character. The causes of the thickening and homogenous transformation are entirely obscure. It has been believed by some writers to be due to a coagulation of proteid material after the death of the cells, or that it is due to a local disturbance of metabolism. According to the latter theory the cells are unable to make use of the proteid material brought to them; this becomes precipitated or infiltrated into the interstitial substance. The cells are thus pushed apart, and gradually atrophy. In many cases the formation of hyalin just beneath the endothelium of the blood-vessels points, as in the case of amyloid, to a secretory action on the part of these cells in removing certain substances from the blood. In the cylindroma and also in the mixed endotheliomata of the parotid, the formation of hyalin appears to be due partly to a secretory action on the part of the tumor cells and partly to a degeneration of these cells. In the case of the lymphatic glands the appearances more often suggest a deposit than a degenerative process. While not bearing the same relation to tuberculosis, chronic suppurations, etc., that amyloid does, hyaline degeneration is most frequently associated with chronic intoxications. Syphilis, lead poisoning, alcoholism, overeating, etc., are conditions favoring or leading directly to hyaline change in the blood-vessels. It is probable that hyaline material can be reconverted absorbed, or removed. The corpora fibrosa of the ovary undergo contraction and decrease of size until they come to consist of a narrow line of hyalin only. Further, hyalin is very unstable, being frequently calcified, converted into myxomatous tissue, or undergoes complete disintegration. The hyalin of sclerotic vessels frequently suffers a fatty change with later formation of cholesterin. The effects of hyaline change upon the tissues are similar to those of amyloid.

Hyalin Bodies.—In this connection should be considered also the so-called hyaline bodies (fuchsinophile bodies, Russell's bodies, etc.) which are frequently found in normal tissues as well as in a great variety of pathological processes. They are globular, hyaline bodies of varying size, often occurring in mulberry-like conglomerations. They may be found both within cells and free in the stroma. With acid fuchsin they stain red, and with Weigert's fibrin-stain a deep blue. They are found particularly in glandular proliferations of the stomach mucosa, chronic inflammatory processes, lymphadenoid tissue, and in malignant tumors. They may occur in either epithelial or mesoblastic cells. Their frequent presence in malignant tumors has led them to be regarded as parasites, either blastomycetes or protozoa. They are almost constantly present in the hemolymph glands where they undoubtedly represent products of the disintegration of red blood cells. In pernicious anemia phagocytes filled with these bodies are found in large numbers in these glands. Many of the bodies give an iron reaction. In other cases the granules may arise from the oxyphile and basophile granules, the process partaking of the nature of a coagulation. The exact chemical nature of hyaline bodies is not known.

The hyaline bodies found in the central nervous system are more closely related to colloid and the corpora amylacea. Under certain conditions in gliomata arising from the spinal cord glistening hyaline masses are formed from degenerating glia cells. The condition is known as *degeneratio micans*. In other varieties of tumors arising from the central nervous system, hyaline masses staining red with fuchsin are frequently found. In the majority of cases they are probably obliterated blood-vessels that have become hyaline.

ALDRED SCOTT WARTHIN.

Hyalitis.—See *Vitreous Body*.

Hyalomma.—A genus of ticks, *Ixodinæ*, in which eyes are present, the rostrum is long, and the male bears two pairs of ventral shields. *H. ægyptium* sometimes attacks man but appears to do no serious harm. See *Arachnida*.

Hyaloserositis.—DEFINITION.—An inflammatory affection of the serous membranes, of chronic and progressive development, characterized by a peculiar overgrowth of fibrous tissue with hyaline metamorphosis.

This disease is a very remarkable one, and, judging from published cases, not often recognized. Examples have been recorded in Germany and Austria chiefly by Hamboursin,[1] Weiss,[2] Curschmann,[3] Vierordt,[4] Riedel,[6] Rumpf,[7] Pick,[8] Schupfer,[9] Siegert,[10] Schmaltz and Weber,[11] Rose,[12] Strajesko[13] in England by Hale White[5]; in America by Nicholls,[15] A. O. J. Kelly,[16] and Herrick.[17]

It is probable, however, that the affection is not so uncommon as the paucity of recorded cases would lead one to suppose, for the existence of the condition has not yet been impressed upon the minds of the general run of the profession, and the unwary would be easily led into errors of diagnosis.

The affection may begin in various ways, so that

differing clinical types are produced. Sometimes the capsule of the liver is chiefly affected, and it is to this class of cases that the terms "diffuse chronic hyperplastic perihepatitis," "chronic deforming perihepatitis," "Zuckergussleber," have been applied. In other cases it is the pericardium or the pleura that is first involved. Nevertheless, in whatsoever way the disease may begin, or in whatever part it may attain its greatest intensity, it is to be noted that the

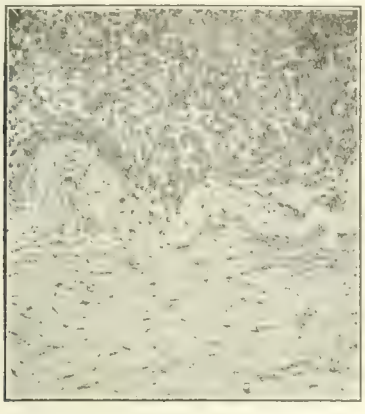


Fig. 3297.—Section of Liver, Showing well the Glisson's Capsule Thrown into Folds with the Deposit of Hyaline Fibrous Tissue upon the Surface. (Nicholls.) (Winckel objective No. 5, without eyepiece.)

process is everywhere essentially the same, since it becomes diffuse and involves one serous membrane after another in a steady progression. Consequently the term *multiple progressive hyaloserositis*, denoting as it does an inflammatory process at once chronic and continuous, and emphasizing the peculiar hyaline change which is so striking an element in the anatomical picture, is perhaps the most suitable term to employ.

Distribution.—The disease appears to be widely disseminated, being found in all countries and all climes; sex appears to have but little importance; the cases hitherto recorded have been chiefly in males. With regard to age, the youngest patient affected was aged four, the oldest eighty years; those below middle age are probably the most likely to be affected.

Morbid Anatomy.—Two types of the affection have been described, the sporadic and the diffuse. Except for peculiarities in localization and extent, these forms are, anatomically speaking, essentially the same. The characteristic lesion is the formation of isolated nodules or continuous sheets upon the serosæ of a pearly white material having a dense, cartilaginous consistency. This substance has been compared to the sugar upon a cake (*Zuckerguss*) and to porcelain. When forming a definite membrane it varies in thickness from a few millimeters to from one to five centimeters, and can be readily stripped off the subjacent organs without injury to their substance. On section this membrane has a semitranslucent, bluish-white almost gristly appearance.

In the sporadic form the material usually forms flattened plaques, but may occur in elevated or even polypoid nodules. The favorite sites of localization are the capsules of the spleen and liver, the diaphragm, and the pleuræ.

With regard to the diffuse form, in the majority of cases the capsules of the liver and spleen, the pericardium and the lower portions of the pleuræ are involved. It is the rule also for more or less implication of the general peritoneum to occur. This results in induration and contraction of the great omentum and the mesentery; the omentum is frequently converted into an irregular tumor-like mass or a thick fibrous cord crossing the abdomen transversely. The contraction of the mesentery leads to dislocation of the intestines so that they lie bunched up along the spinal column. Bands of adhesions, fibroid and velamentous in character, are found connecting adjacent structures and are likely to be met with between the liver and spleen and the diaphragm and between the coils of intestines. While all or most of the serous membranes are involved in the process, they do not all present the same grade of affection. Thus, while one membrane presents the typical "icing" appearance, the other serous sacs may be obliterated by simple fibroid adhesions or traversed by bands, or in other cases may contain a serofibrinous or fibrinopurulent exudation. When affecting, as the process usually does, more than one serous sac, no order of involvement is absolute, and combinations are numerous.

In the perihepatic form, where the brunt of the disease falls upon the liver and diaphragm, the liver is usually diminished in size and much altered in shape, becoming somewhat globular; the edges are rounded and the anterior border is often rolled back upon the upper surface. The gall bladder is usually contracted and enclosed in a dense mass of hyperplastic tissue. The surface of the liver, after the investing crust is removed, which may readily be done, is smooth or at most slightly uneven. On section the organ usually

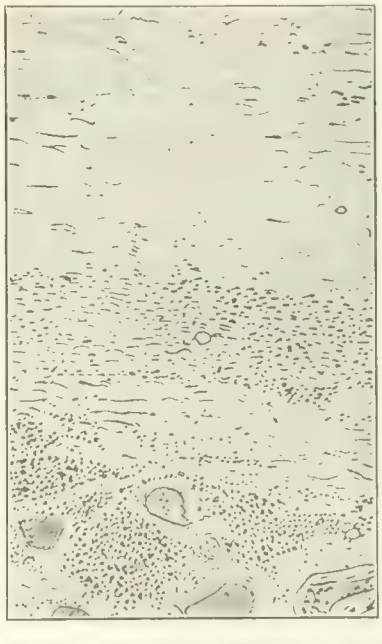


Fig. 3298.—Section of Peritoneal Membrane in the "Zuckerguss" condition, Showing Perivascular Leucocytosis and Hyaline Degeneration of the Superficial Fibrous Tissue. (Nicholls.) (Camera lucida drawing; Reichert objective No. 3.)

shows brown atrophy, fatty degeneration, with some passive congestion. Cirrhosis of the organ does not occur as a rule; at most there is a slight thickening of the septa passing in from the capsule. The spleen is often enlarged, generally covered with the "icing" membrane, and deformed. With regard to the pleuræ, the right is as a rule more seriously involved than the left; the bases of the sacs are the sites of election for the process. The lungs are usually atrophied and partially collapsed. Chronic adhesive pericarditis, or more correctly, mediastinopericarditis, is frequently found. More rarely an acute exudative pericarditis is present, and more rarely still the peri-

cardium may be normal. Occasionally the pericardial sac is only partially obliterated, and then the adhesions are denser on the right side toward the diaphragmatic surface. Calcareous deposits are sometimes met with in the adhesions. The heart is often small and may show the results of pericardial adhesion, namely, dilatation and insufficiency of the valves.

The kidneys in most instances show no special abnormality except possibly congestion. In a few cases interstitial fibrosis has been found. The digestive tract shows but little disturbance; the stomach and colon may be found adherent to adjacent parts. A duodenal ulcer was found in one case. Icterus is never present, unless the case is complicated by cirrhosis of the liver or by obstruction to the common bile duct. As complicating conditions which hasten the fatal termination, acute pneumonia, pericarditis, pleurisy, peritonitis, and osteomalacia may be mentioned. A striking feature of the diffuse form is ascites, which is usually extreme. The ascitic fluid is of pale straw color, high specific gravity, containing flakes of fibrin, and has all the appearances of an inflammatory exudate. Anasarca is usually not marked until toward the end.

In addition to the form just described it should be stated that an increasing number of cases of serositis of this hyperplastic type are being reported as due to tuberculosis. It is beginning to be recognized that tuberculosis is not necessarily destructive, but, on the contrary, may be constructive—instead of extensive caseation and softening we may have the formation of a hyperplastic hyaline membrane with little or no caseation. In many cases it is only the discovery of the specific bacillus which will reveal the true nature of the process. It used to be thought that cases of the perihepatic or "Zuckergussleber" type, to which Curschmann first drew attention in his classical paper, were never due to tuberculosis; but that is certainly incorrect. Strajesko[14] and James B. Herrick[17] have recorded typical cases undoubtedly of tuberculous origin, and the writer has observed similar instances.

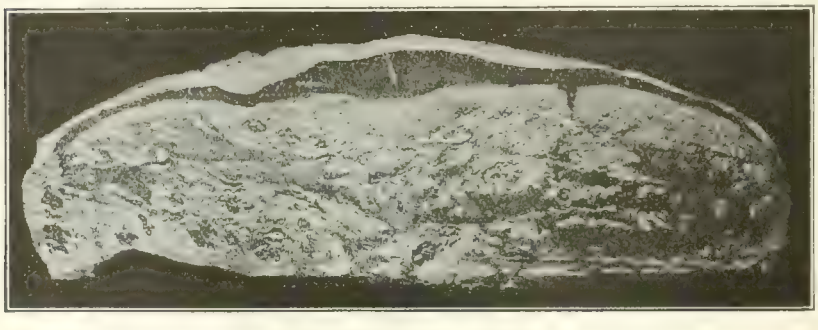


Fig. 3299.—Tuberculous Perihepatitis. The illustration shows the thick hyaline and caseous membrane produced in the chronic hyperplastic type. (Nicholls.)

Hyperplastic tuberculosis of the serous membranes is in my experience not very uncommon, but it is certainly rare for it to attack the capsule of the liver, the pericardium, and the right pleura in such a way as to simulate Curschmann's "icing" liver and atrophic cirrhosis. The lesions produced are not unlike those of the simple or non-tuberculous form, the main difference being that the process is not so liable to be concentrated on any special organ, but is more generalized over the serosæ. Again, ascites is usually less marked and fibroid adhesions are more numerous. The membrane produced is rarely smooth and glistening, but is covered with fibrin and shaggy adhesions. A hypertrophic fibro-hyaline membrane may be produced also in this form, but in it caseous masses can generally be made out, disclosing the etiology of the case; the caseation may, however, be very trifling.

Microscopically the membrane in the simple form is composed of parallel laminæ of connective tissue showing marked hyaline thickening of the fibrillæ. In the deeper portions newly formed capillaries can be made out with some perivascular leucocytosis, and "Mastzellen" are numerous. *Macroscopically* the membrane has all the appearance of an organizing deposit upon the serosæ—a deposit in which hyaline degeneration constitutes the most striking feature. In the tuberculous form the connective-tissue fibrillæ interlace freely, and there are usually multiple areas of caseation with numerous giant cells. Hyaline degeneration is also present, but is rarely so marked as in the simple form. Tubercle bacilli can usually be demonstrated readily on making smears from the deposit.

In the tuberculous form, unlike the first variety, the liver is usually enlarged and often shows signs of miliary tuberculosis with slight interstitial fibrosis. Old tuberculous foci are usually found in the lungs, pleuræ, and peribronchial glands. The case often terminates with a generalized miliary infection.

Etiology and Pathogenesis.—Several views have been advanced as to the causation of the disease. The first is that of Pick, who regards the primary condition as an adhesive pericarditis which leads to portal obstruction and the so-called "cardiac" cirrhosis of the liver, eventually resulting in ascites and thickening of the liver capsule. For this condition he has proposed the somewhat clumsy title, "Pericarditic pseudocirrhosis of the liver." The objections to Pick's view briefly are, that cases occur in which pericardial adhesion is absent, there is usually no cirrhosis, and in most of the recorded cases it has been shown that portal stasis was not present; nor, again, does the development of the physical signs accord with what should occur were Pick's view correct. Pick himself has admitted that there is no true cirrhosis of the liver.

Hale White lays stress on the influence of nephritis in the etiology. It must be said that the vast majority of those who have carefully studied the question are agreed that the overgrowth of fibrous tissue and the ascites are due to an inflammatory process involving the various serosæ. Most cases give a history of some previous acute inflammatory disease, and the development of the lesions can usually be traced from one serous membrane to another. Cases have been known to follow acute rheumatism, endocarditis, typhoid fever, whooping-cough, measles, malaria, and perityphlitis. The transmission of the infective agents from one serous sac to another takes place by means of the lymphatics. In the tuberculous form, which is anatomically comparable to the simple type, the true character of the disease is of course obvious. With regard to the ultimate nature of the process in the simple form, some little doubt must still exist; but it is probable that microorganisms of low virulence are at work. We cannot take the extreme position of Piccini, Hager, and Concato, that all cases of subacute and chronic polyserositis are due to tuberculosis.

The writer has noticed that the form characterized by the production of isolated nodules on the surface of the spleen or liver appears to be specially associated with passive congestion of these organs. This suggests the possibility that obstructive cardiac dis-

ease of valvular origin might be an etiological factor in the diffuse disease. No instance of this had been observed at the time of the publication of his original monograph, but some few years later he had an opportunity of observing a case that illustrated this etiology. A middle-aged woman, suffering from mitral stenosis, ascites, anasarca, and all the signs of deficient compensation, was under observation at varying periods for ten years. The valvular process progressively involved the aortic and tricuspid orifices and the ascites necessitated frequent tapping. When she died there was typical hyaloserositis of the liver, spleen, omentum, and peritoneal serosa, and of both pleural cavities. Here it is barely possible that through frequent tapping the abdominal cavity had become infected and thus given a starting point for an inflammation gradually involving other cavities, yet undoubtedly the infective nature of the progressive valvular affection would be sufficient to account for it. The rôle played by passive congestion is exhaustively discussed by Hess in an admirable monograph.[18]

The inflammatory process usually begins in the peritoneal cavity in the form of a hepatitis or perihepatitis, or, more rarely, about the stomach and duodenum; it extends to the right pleura and eventually to the pericardium. Next in frequency, the primary lesion is a pericarditis with adhesion extending to the right pleura and thence to the peritoneum; more rarely still, chronic pleurisy may extend to the liver capsule. The process is accompanied by an exudation of serofibrinous fluid into the abdominal cavity, which fluid tends to be abundant owing to the involvement of the absorptive surface of the peritoneum by the dense fibrous deposit, and also from the fact that the contracting fibrous masses sometimes lead to pressure upon the inferior vena cava and portal vein. Many cases, however, present no evidences of portal obstruction. The liver gradually diminishes in size, and the spleen becomes enlarged in the later stages when passive congestion becomes marked. Gout and alcoholism appear to have little to do with the process. Syphilis has been known to produce chronic adhesive and membranous peritonitis (Lancereaux), but as yet no case of multiple hyaloserositis has been recorded as due to this cause.

If we accept, as I think we must, that multiple progressive hyaloserositis is an inflammation of serous membranes of an infective origin and progressive character—a view that is supported by analogy, by the available anatomical evidence, and the clinical course, this brings the affection into line with the acute and subacute forms of serous inflammation. Acute polyserositis has been much studied and a considerable literature has gathered about the subject. It is variously known as, acute polyserositis, acute multiserositis, acute polyseritis, polyorrhomenitis (a barbarous term), Concato's disease, and Bamberger's disease. Undoubtedly, acute inflammation beginning in one serous cavity may spread to other serous membranes, becoming in time subacute and chronic, finally leading to fibrous adhesion and notable changes in the organs involved. This inflammation, however, need not come to an end but may be progressive and characterized by the appearance at intervals of fresh exudation. Occasionally, the fibrinous deposits become hyaline, hence "hyaloserositis." On the other hand, hyaloserositis may be so insidious in its onset that it is hard to assign its incidence to any particular time or to any primary localized process. Consequently, while multiple progressive hyaloserositis must be regarded, etiologically and pathogenetically, as of the same order as the acute forms of polyserositis, yet its anatomical features and clinical course are so remarkable and distinctive as to merit a separate description and almost constitute it a disease *sui generis*.

Clinical Course.—The sporadic form, being entirely of pathological interest and giving rise to no characteristic symptoms, may be dismissed from consideration. In the diffuse variety, the most striking clinical features are those to which Curschmann first drew attention, namely, shortness of breath, slight general weakness, and a gradually increasing and refractory ascites. The resemblance to atrophic cirrhosis of the liver is striking. Most cases begin insidiously and give a history of indefinite disturbance from the first, such as anorexia, dyspnea, and epigastric pain. In other cases the disease begins acutely with fever, rigors, and epigastric pain, during which time the liver region becomes tender and swollen. The affection ultimately becomes chronic and periods of latency alternating with exacerbations are the rule.

According to the manner of onset we can recognize two main types: first, the *perihepatic*, and second, the *mediastinopericardial*.

In the first, after more or less evidence of involvement of the liver capsule, such as pain and tenderness in the right hypochondrium, with or without fever, ascites develops and the liver is found to be enlarged. It is frequently observed later that one or both of the pleural cavities contain fluid, or the mobility of the lungs is impaired by adhesions. Finally, in most cases, although exceptions occur, there develop evidences of adhesion of the pericardium, and dilatation of the veins of the neck, chest, and arms may be noted. As the disease becomes well established the liver becomes smooth, hard, and gradually contracts, while the spleen steadily enlarges and may become palpable. Anasarca appears only in the later stages.

In the second type, the earliest signs are referable to an indurative mediastinopericarditis, namely, pain in the chest, cough, palpitation of the heart, dyspnea, cardiac dilatation, and possibly the pulsus paradoxus and systolic retraction of the chest wall. Signs of pleural effusion or adhesion appear and the process eventually spreads to the liver capsule. As before, the liver is large and smooth, but contrary to what occurs in the perihepatic form, anasarca is an early, though it may be a transient sign. As time goes on the liver decreases in size and ascites makes its appearance.

In all forms, eventually, paracentesis becomes necessary and must be repeated at gradually diminishing intervals. The condition of the liver and spleen can be made out only after free tapping. Digestive disturbances when present are trifling, such as anorexia, constipation, or diarrhea; jaundice does not occur in uncomplicated cases. Albuminuria is found occasionally and is attributable to passive congestion of the kidneys. Fever is usually absent except during an exacerbation or complication. The disease is essentially chronic, lasting for from two to sixteen years. The sufferers may not be seriously incapacitated for work for long periods, but the condition proves singularly refractory to treatment and relapses are frequent. Death occurs usually from some acute complication, lobar pneumonia, or peritonitis.

The tuberculous form of the disease, as the cases of Strajesko and Herrick have shown, may occasionally present almost exactly the clinical picture of the "icing" liver of Curschmann's description. Little is known of this form as yet, but, so far as my experience goes, the only differences between the simple or non-tuberculous and the tuberculous forms are, that in the latter the liver remains enlarged to the end, fever is more constant, and the disease tends to run a more rapid course. In fact, most cases of tuberculous origin run a course very similar to that of chronic tuberculous peritonitis, with the addition of evidence of the involvement of the other serous membranes. There is little in the physical signs to suggest a chronic hyperplastic lesion rather than an exudative one in these cases, unless the liver capsule is chiefly involved. Unlike what takes place in the non-

tuberculous form, ascites is rarely extreme and sacculation of the abdominal fluid is more likely to occur. Usually, too, the disease begins with signs of tuberculous involvement of the lungs, pleuræ, peribronchial glands, or, in the female, the tubes and ovaries.

Diagnosis and Prognosis.—The diagnosis lies between chronic hyperplastic perihepatitis, atrophic cirrhosis of the liver, and carcinoma of the peritoneum, for in all there may be ascites, more or less abdominal pain, and, in most, induration of the great omentum. The combination of extreme ascites with relatively little anasarca, an adhesive pericarditis, pleural exudation, or adhesion, particularly if on the right side, should always arouse a suspicion of multiple progressive hyaloserositis, and especially perihepatitis.

Table of Differential Diagnosis

Special features.	"Zuckergussleber."	Atrophic cirrhosis of liver	Chronic tuberculous peritonitis.	Carcinomatous peritonitis.
Age	Occurs about middle life	Oftenest about middle age	Commonest between ages of twenty and forty	Occurs late in life
Sex	Slight predominance in favor of males	More frequent in males	Predominates in females	More frequent in females
Previous history	Often a history of acute pericarditis or perihepatitis	History of alcoholism, syphilis, or digestive disturbances.	Often a chronic cough, diarrhea, or general tuberculosis.	In some cases a history of cancer of stomach, mamma or ovaries.
Alcoholism	No influence	Frequently present	Unimportant	Unimportant
Syphilis	No influence	Occasionally present	Unimportant	Unimportant.
Heredity	No influence	Unimportant	May be distinctly latent	Unimportant.
Incidence	Acute, becoming chronic or insidious from the first	Insidious	Onset may be acute or subacute	Insidious
Chronicity	Cases last for years	May last for years	Prolonged	Usually rapid course, with cachexia.
Fever	Generally absent except during exacerbation or some complication.	May be afebrile when present is slight	Usually slight, often absent.	Rarely absent; due to complications.
Pain	Indefinite and trifling....	Trifling	Apt to be troublesome.	Variable
Digestive disturbance	Trifling or none	Constant dyspepsia, vomiting, gastric hemorrhage, melena.	Fairly common.	Often marked.
Ascites	Constant and extreme	Constant	Never extreme; may be absent; may be hemorrhagic.	Moderate grade; may be hemorrhagic or pseudochylous
Anasarca	Constant but slight	Relatively slight	Trifling.....	Slight.
Jaundice	Absent in pure cases	Occurs in twenty-one per cent. of cases.	May occur exceptionally	Common, when liver is involved.
Liver	Not cirrhotic; at first enlarged, then small; smooth.	Cirrhotic; at first enlarged, then small and warty	Often enlarged	May be enlarged, with nodules.
Spleen	Gradual enlargement	Gradual enlargement.	Nothing special	Nothing special.
Omentum.	Thickened and contracted	Normal	Often matted up	Often matted up.

Perihepatitis is differentiated from atrophic cirrhosis by the fact that portal congestion does not occur except much later on and is never marked; secondly, severe digestive disturbances, such as dyspepsia, vomiting, hematemesis, and melena, are not present. Jaundice does not occur except in the rare event of a mixed cirrhosis accompanying perihepatitis, a case of which has been recorded by Rose.[12] The liver is never warty; signs due to cholemia do not occur. Further, the great omentum is nodular and contracted, while in cirrhosis it never is.

In carcinoma of the peritoneum, when the liver is enlarged, jaundice is often present, the course is fairly rapid, cachexia and digestive disturbances are marked. There is usually some evidence of cancer of the stomach, mamma or ovaries.

Having diagnosed the presence of chronic perihepatitis, it is next necessary to determine if it be tuberculous or not. In the tuberculous form ascites is rarely so extreme; abdominal pain and tenderness are apt to be more marked and the liver is enlarged throughout. Careful examination of the lungs, lymphatic glands, testes, ovaries, and Fallopian tubes, as well as of the urine, feces, and sputum, should be made. In suitable cases tuberculin injections should be tried. The preceding table presents in a convenient form the main points characterizing the various infections likely to be confused. Diagnosis may, however, be very difficult and perhaps impossible.

The prognosis should be guarded; the disease is essentially chronic and may last for years without seriously incommoding the patient. The simple form is steadily progressive and invariably fatal. The tuberculous form is also practically always fatal, but may possibly heal after suitable interference. Tuberculous cases and those complicated with adherent pericardium run a more rapid course than the others. The special risk to life arises from some intercurrent complication.

Treatment.—No specific medication has been devised. The chief point is to meet the symptoms as they arise. Pain may be relieved by hot fomentations and opium. To relieve the ascites, diuretics have been recommended, notably caffeine in doses of 0.1 to 0.15 gram six to ten times daily; digitalis and diuretin may be tried. When ascites is extreme, tapping must be resorted to. Some cases, especially the tuberculous forms, may be benefited by laparotomy. Needless to say, the patients must be kept under the best hygienic surroundings.

Albert George Nicholls.

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Hydramnion, Hydramnios.—The normal quantity of amniotic fluid at full term is from 400 to 1,000 c.c. An excessive accumulation of this fluid is known as hydramnion; ten to fifteen times the normal amount may be present. As much as thirty liters (quarts) has been seen. A slight excess is probably of frequent occurrence, and passes unnoticed, but an increase over two liters is very likely to give rise to symptoms. In the majority of cases the formation of the fluid is slow at first, but toward the end of pregnancy it increases at a more rapid rate. Occasionally the fluid may accumulate very rapidly, giving rise to serious symptoms from the sudden distention of the uterus (acute hydramnion). The condition is said to occur in one of every 100 cases of pregnancy. It usually develops in the fourth to sixth month. Hydramnion in itself is not a disease, but is to be regarded as a secondary condition to many widely differing processes, of both the fetus and of the mother.

No constant pathological changes in the amnion itself have been found in this condition; fissuring of the epithelial layer, fatty degeneration of the epithelial cells, etc., have been described. Hypertrophy of the decidua and hyperplasia of the chorionic villi have also been found in cases of hydramnion, but the connection between these conditions has not been proved. Neither physiological nor chemical investigations as to the composition of the fluid have yielded positive information as to its source. The fluid is usually described as identical in appearance and composition with normal amniotic fluid, although some writers claim that the urea content is sometimes increased. According to Opitz, the fluid of hydramnion contains a lymphagogue substance that is normally absent. That the fluid is not always derived from the fetal kidneys is shown by the fact that hydramnion may occur in cases in which the passage of urine from the fetus is impossible.

The etiology of hydramnion is in many cases obscure. Inasmuch as the question of the origin of the normal amniotic fluid remains unsettled, we are not yet in a position to solve the more complicated problem of the manner of formation of the fluid under pathological conditions. The view most generally held at the present time that the normal fluid is the product of both fetal and maternal structures is borne out by the fact that hydramnion is produced by or at least accompanies pathological changes in both mother and fetus. We may therefore distinguish two classes of hydramnion, one of fetal origin, the other of maternal.

Hydramnion of Maternal Origin.—Hydramnion due to pathological conditions of the mother is of much less frequent occurrence than that associated with disease processes of the fetus. It occurs particularly in anemic, dropsical, tuberculous, leukemic, and syphilitic women. In pneumonia, hepatic cirrhosis, failure of compensation in valvular lesions, and all other conditions leading to venous stagnation in the maternal body, hydramnion may occur. In such cases the condition is usually chronic, but acute heart failure with sudden development of ascites or general edema may lead to an acute hydramnion. Loss of tone of the uterine wall is also said to favor the production of an excessive amount of amniotic fluid. Hydramnion is very likely to recur in successive pregnancies of the same individual.

Hydramnion of Fetal Origin.—Hydramnion occurs frequently in connection with ascites and general edema of the fetus caused by cardiac and renal disease, and syphilis of the lungs and liver; less commonly in cases of obstruction of the ductus Botalli, stenosis of the umbilical vein, twisting of the cord, velamentous insertion of the cord, fetal tumors interfering with the circulation, tumors of the placenta, placental hypertrophy, hydrocephalus, anencephalus, etc. In general, any condition raising the blood pressure in the umbilical vein and placenta may give rise to hydramnion. The association of hydramnion with fetal abnormalities is very striking; about fifty per cent. of cases show some serious malformation, such as harelip, club-foot, spina bifida, etc., in addition to those mentioned above.

Hydramnion has also been explained as being due to a persistence of the vasa propria of Jungbluth, but the presence of these vessels in the late stages of pregnancy is considered by some writers to be secondary to an increase of blood pressure in the umbilical vein. Excessive urinary secretion in fetal diabetes and cardiac hypertrophy, increased activity of the fetal skin, serous inflammations of the amnion, deficient absorption of the amniotic fluid, and increased activity of the chorion are other causes assigned by various authors. Both fetus and mother may under rare conditions contribute to the formation of the increased amount of fluid. This occurs most frequently in cases of syphilis of both mother and child when both are dropsical.

A more recent theory for the explanation of hydramnion is based upon the hypothesis that there is in the fetal blood a substance which causes an increased passage of fluid from the maternal vessels to those of the chorion, so that the fetus becomes plethoric. As a result of the plethora the heart's action is increased, and this in turn leads to increased urinary secretion. The lymph-forming substance, being excreted in the urine, passes into the amniotic fluid. When the latter is swallowed by the fetus the substance is again absorbed into the fetal blood and a vicious circle is thus set up. This hypothetical substance in the end produces toxic effects upon the liver and kidneys leading to fetal dropsy.

Hydramnion is not infrequently associated with unioval twin pregnancy, in that in the case of one fetus there is a normal or lessened amount of amniotic fluid while in the case of the other there is hydramnion and hypertrophy of the fetal organs. This has been explained in various ways, but none of the theories presented is adequate. According to Kustner one of the twins receives more abundant nourishment than the other, and this overnutrition leads to increased heart action and resulting cardiac hypertrophy. Increased urinary secretion into the amniotic sac consequently follows and causes an increase in the amniotic fluid. Ultimately insufficiency of the heart

occurs with venous stasis and liver cirrhosis, both of which factors add to the hydramnion already existing. According to Schatz one fetus transfuses more blood into the circulation of its twin than the latter gives back to it, whereby the heart of the latter becomes hypertrophic and increased urinary secretion follows. Against both of these theories may be raised the objection that in the circulation of the twins a condition of equilibrium must ultimately be reached so that in one case blood must transfuse from the circulation of the stronger to that of the weaker; and in the other, as soon as the hypertrophic heart becomes insufficient, the normal heart of the weaker fetus must act relatively with much greater strength than the insufficient hypertrophic one. In the case of twins arising from two ova either one or both sacs may become hydramniotic.

Symptoms.—In acute hydramnion the sudden distention of the uterus causes intense pain, and there are extreme dyspnea, cyanosis, frequent and severe vomiting, and fever. In chronic hydramnion the symptoms are very much like those of cystic ovarian tumors. As the uterus becomes more and more distended it may give rise to pressure symptoms, dyspnea, pain in the sides, edema of legs and genitals, varices, etc. In cases of very gradual development the uterus may attain a very large size without causing much discomfort.

Diagnosis.—Hydramnios must be differentiated from ascites, ovarian cystomas, distended bladder, and multiple pregnancy. Palpation and percussion are usually successful in establishing the presence of a readily ballottable fetus in the distended uterus. Fetal heart sounds are indistinct.

Prognosis.—The pressure symptoms may be so severe as to endanger life, but inasmuch as the process may be controlled by the production of abortion the prognosis, in so far as the mother is concerned, is a favorable one. In the majority of cases the fetus is either underdeveloped or malformed, only about one-third of the children surviving. Hydramnion of moderate degree may produce no symptoms and does not endanger either fetus or mother.

Treatment.—Against the formation of hydramnion there are no therapeutic measures of avail. When the fluid accumulates in such large quantity or so rapidly as to produce serious symptoms, relief by evacuation is indicated. This is accomplished by rupturing or puncturing the membranes and allowing the amniotic fluid to escape. Premature labor usually follows this procedure and the fetus, in case it has not reached a viable age, is lost. Premature labor usually occurs spontaneously if the patient is left alone and the children are usually poorly developed, so that the termination of pregnancy is indicated at whatever stage the condition presents itself. Mild chronic cases may be treated by enforced rest of the mother, and by the use of a binder. In the mild cases no treatment is necessary, but it is to be remembered that in such cases abnormal presentations of the fetus are of frequent occurrence.

Aldred Scott Warthin.

Hydrangea.—"Seven Barks." The dried root of *Hydrangea arborescens* L. (fam. *Saxifragaceæ*). This is a medium-sized shrub with softish stems, opposite, glabrous, ovate, serrate, bright green leaves, and flattish cymes of greenish flowers. It is a native of the middle, and especially of the southern United States. The root is very much and crookedly branched, from a knotty crown an inch or two in diameter, and is usually cut into pieces from one to several inches in length before marketing. The largest of these roots are usually of about the thickness of the little finger. The color is a very pale grayish-yellow, with rusty yellow patches and streaks, but the bark has a great tendency to peel off, leaving the nearly white, very smooth wood exposed. The wood is light, tough, and splintery, and is tasteless and inactive. The bark is first sweetish and feebly aromatic, then slightly acrid.

It contains starch, a little resin, saponin, and a crystalline glucoside (hydrangin, $\frac{1}{10}$ per cent.). It has had some employment in urinary disorders, especially those accompanying "gravelly deposits," and is mildly diuretic. Dose gr. xxx. to ʒ i. (2.0–4.0).

Henry H. Rusby.

Hydrargyrum.—I. General Medicinal Properties of Compounds of Mercury.—All mercurials capable of gaining entrance into the circulation are competent for a certain peculiar influence over nutrition, as follows: In small dosage the tendency is, as in the case of iron, to increase the quantity of hemoglobin present in the blood—an effect trifling in the case of a person in good health, but distinctly marked in an anemic syphilitic patient. In the syphilitic, furthermore, mercury tends to shorten the course and lessen the severity of the eruptions and inflammations due to the disease. In large dosage, or in too rapidly pushed small dosage, the effects become deleterious. The albumin and fibrin of the blood are lessened in amount, coagulability is impaired, and degeneration and absorption of tissue, and inflammation of certain glands and other structures follow. These phenomena, constituting general mercurial poisoning, may lead to long-continued impairment of health, or even to death. In the medicinal induction of the constitutional mercurial influence, or *mercurialization*, as it is commonly called, it may be necessary, for the gaining of the full therapeutic benefit, to push the dosage until the verge of poisoning be reached, but never further. The symptoms of incipient mercurial poisoning thus become of clinical importance, and are as follows, taking their character from the fact that the salivary glands and buccal structures are peculiarly obnoxious to the poison: *Subjectively*, there are noticed a metallic taste in the mouth, and a little soreness in the sockets of the teeth on bringing the jaws sharply together. *Objectively*, the gums are observed to suffer from a slight inflammation, of which the signs are, first, but very transiently (often escaping notice altogether), an unnaturally white appearance from unduly rapid proliferation of epithelium. This aspect soon gives way to the classical picture of red, swollen, and spongy gums, and along with the development of this condition begin an increased flow of saliva and a little tenderness, perhaps even swelling, of the parotid glands. Simultaneously, there may be a deranged stomach, relaxed bowels, and general mild malaise with a trifle of fever, and unnatural susceptibility to "catching cold." All these symptoms disappear readily and completely on stopping the medication. Beyond them, the effects belong wholly to the category of the poisonous, for the discussion of which see the following article.

An important point of obvious clinical bearing is that in childhood ages—and the younger the more marked—the symptoms of incipient poisoning differ from the picture just given in that the salivary apparatus is comparatively insensible to the mercurial irritation. In other words, children are not easily salivated in the strict etymological meaning of the word. But while this is literally so, it does not follow, and in point of fact is not true, that children are not proportionately as much blood-poisoned by mercury as are adults. Rash over-mercurializing of children, because of the false security drawn from the non-appearance of salivation, may therefore lead to disastrous effects.

The deranging effect of mercury, as thus sketched, upon the human organism, is but a single exemplification of a general tendency which the metal has to

poison all living things, animal or vegetable, high or low in the organic scale, alike. Few poisons, indeed, are so universally and so intensely obnoxious to life generally as is mercury. To the low organisms especially, that are associated with the processes of putrefaction and fermentation, mercury is powerfully poisonous, and the soluble mercurial preparations are therefore highly antiseptic.

For discussion of the *absorption* and *elimination* of mercury, see article on *Hydrargyrum, Poisoning by.*

As regards *local* effects there is great difference among the individual mercurials. In general the *mercuric* compounds are more or less decidedly irritant, though not astringent; while the *mercurous* compounds and the preparations containing mercury in the metallic state, are either quite bland or only mildly irritant. In the alimentary canal, all mercurials show a decided tendency to relax the bowels, which, with the large doses possible with the milder mercurials, may develop into full purging. In such case the stools are mucous in quality, and are notable for the considerable amount of bile which they contain. By the very virtue of this purgative effect a mercurial purgative dose is itself hurried along the intestines and discharged per anum before time has sufficed for absorption. The *mild insoluble mercurials* are thus possible of application as simple laxatives or cathartics. The *irritant* mercurials, taken internally, even in small medicinal dosage, have an annoying tendency to irritate the stomach as well as the bowels, and loss of appetite, with epigastric uneasiness and tenderness, and perhaps nausea, often follow so quickly the beginning of a course of a mercuric salt that the medication has to be discontinued or changed. In large doses the *mercuric* compounds are powerful irritant poisons—the more soluble ones, such as corrosive sublimate, even intensely so. Death may follow in the case of poisoning by the latter compound, by sheer irritation, before the mineral has time to work any specific constitutional mercurial effect (see article *Hydrargyrum, Poisoning by*).

Therapeutically, mercurials are of manifold application. *Constitutionally,* general mercurialization is wellnigh universally applied in the treatment of syphilis, and in older times, more than now, was used in the treatment of other cachexias also. *Locally,* in the alimentary canal mercurials are used to check vomiting, to purge and to correct digestive disorders, even of incongruous kinds. *Externally,* parasites, vegetable and animal, can be destroyed, ulcers and sores coaxed to healing, and eruptions (especially if syphilitic) to disappearance, and wounds successfully treated on so-called "antiseptic" or "aseptic" principles.

II. The Preparations of Mercury Used in Medicine.—The compounds of mercury affording mercuria-medicines, official in the United States Pharmacopœia, are as follows:

1. *Mercury Uncombined.*—Hydrargyrum, metallic mercury, in bulk; metallic mercury, in fine subdivision, by trituration with an excipient.

2. *Mercurous Compounds.* Chloride (*Mild Chloride, Subchloride, Protochloride, Calomel*); Iodide (*Protoiodide, Yellow Iodide, Green Iodide*).

3. *Mercuric Compounds,* Oxide, (*Red Oxide, Binoxide, Peroxide, Red Precipitate*); Oxide, (*Yellow Oxide, Binoxide, Peroxide*); Chloride (*Bichloride, Perchloride, Corrosive Chloride, Corrosive Sublimate, Sublimate*); Iodide (*Red Iodide, Biniodide, Periodide*); Nitrate; Oleate.

Mercury Uncombined.—Hydrargyrum, Mercury, or Quicksilver. Mercury in bulk is ordinarily not affected by any of the fluids of the skin or digestive tract, and so is without medicinal effect. It is seldom or never used in this form now; formerly it was occasionally employed to overcome mechanically an intestinal obstruction, which in some cases it succeeded in doing. For such purpose, from a few ounces to a pound or two of the metal were swallowed at a draught. Rarely, constitutional effects followed such administration, but generally the metal passed down the alimentary canal unchanged.

Mercury in fine subdivision—"extinguished" by thorough trituration with some excipient, acts, generally, like the mercurous compounds, producing specific mercurial effects, local and constitutional. Undoubtedly, therefore, the metal in these trituration preparations is changed into some soluble mercurial salt by the juices of the part to which it is applied, but the nature of the reaction is very obscure. The trituration preparations of the United States Pharmacopœia are as follows:

Massa Hydrargyri: Mass of Mercury, "Blue Mass," "Blue Pill." Metallic mercury is triturated with honey of rose and glycerin until "extinguished"; liquorice and marshmallow roots in due proportion are then added, and the whole is again subjected to trituration "until globules of mercury are no longer visible under a lens magnifying at least ten diameters." (U. S. P.) The product is a dull indigo-colored pill mass, containing thirty-three per cent. of mercury. No weight of individual pills, be it observed, is directed by the United States Pharmacopœia. Blue mass is used only for internal medication, and behaves like calomel in milder degree. In single large dose it is mildly laxative, producing bilious stools; in small repeated dose it affects the system at large, mercurializing promptly and efficiently, but yet with a tendency to relax the bowels. Therapeutically, blue mass is applied to correct disorders of the alimentary apparatus, or to mercurialize generally, in treatment of syphilis. For the former purpose a single dose is given, generally at night, ranging from 0.30 to 1 or even 1.50 gm. (from gr. v.–xv. or xx.). If the smaller of these quantities be prescribed, a brisk purge is commonly ordered to be taken the following morning on rising, to insure the discharge of the mercurial from the bowel; but if the larger doses be given, the blue mass may "work itself off" by its laxative power in such quantities. To *mercurialize* by means of blue mass, from 0.30 to 0.60 gm. (gr. v.–x.) of the medicine should be a day's allowance, broken up into at least three doses, equidistant in time; the administration being continued either until the therapeutic point is gained, or until the forerunning symptoms of salivation warn to stop. Should the bowels become unduly relaxed, 0.01 gm. (gr. $\frac{1}{6}$) of opium should be added to each pill. Blue mass is prescribed in pill form, three grains to each pill, ordinarily.

Hydrargyrum cum Cretâ, Mercury with Chalk, "Gray Powder." Mercury is shaken with clarified honey, in a strong bottle, until globules of mercury are no longer visible under a magnifying power of four diameters. The product is then triturated with a thick cream of prepared chalk rubbed with water, and the whole then dried and reduced to a uniform powder. The resulting preparation is a smooth, light gray powder containing thirty-eight per cent. of mercury. Being practically all metallic mercury and chalk, it is insoluble in water. Mercury with chalk is naturally very mild, yet in some samples causes irritation, an effect that may possibly be due to contamination with arsenic or antimony, but which probably is more commonly caused by the slow conversion of a portion of the mercury into mercuric oxide. This contamination with mercuric oxide may be detected by treating a portion of powder with dilute hydrochloric acid, and adding stannous chloride to the resulting clear solution. If mercuric oxide be present a black precipitate falls. And for safety's sake, if a sample of mercury with chalk be kept for any time, this test should occasionally be applied.

The action of mercury with chalk is substantially that of blue mass, but weaker, and with less tendency to relax the bowels. The influence of chalk, indeed,

is to constipate, and so it comes about that in the average dose little laxative effect is produced by gray powder. Constitutionally, despite its mildness, the preparation is competent to mercurialize, and for the very reason of its mildness is particularly serviceable when the object is to maintain a gentle mercurial influence steadily for a considerable time, as in certain methods of treating syphilis. For such purpose two or three centigrams (from gr. ¾ to 1) should be prescribed three times daily. If rapid and sharp mercurialization is called for, a more active preparation must be selected. But the commonest application of mercury with chalk is for the correction of disorders of the alimentary apparatus, particularly those, so common in children, where the prominent symptoms are malassimilation of the food with fermentation and diarrhea, or where clay-colored stools occur, whether with diarrhea or with constipation. In such affections gray powder may be given, best in quite small but frequently repeated dosage, such as a centigram or two (one-sixth to one-third of a grain) every hour for a day, unless improvement be sooner effected. Such medication should not be persisted in beyond a day or so, else mercurialization will ensue. The medicine can be taken clear, as a powder, since it has little taste, or it may be put into any convenient mixture. The pill form is bad for gray powder, since by too much pressure the globules of mercury in the preparation are apt to run together.

Hydrargyrum Ammoniatum, Ammoniated Mercury, $HgNH_2Cl$, contains between seventy-eight and eighty per cent. of metallic mercury. It is also known as White Precipitate. It occurs in "white, pulverulent pieces, or a white amorphous powder, without odor, and having an earthy, afterward styptic and metallic taste; permanent in the air, insoluble in water or in alcohol." (U. S. P.)

Unguentum Hydrargyri Ammoniati, Ointment of Ammoniated Mercury contains ten per cent. of ammoniated mercury. It is sometimes called White Precipitate Ointment.

Unguentum Hydrargyri, Mercurial Ointment, formerly also known as "Blue Ointment." It contains fifty per cent. of mercury.

Unguentum Hydrargyri Dilutum, Blue Ointment, contains sixty-seven per cent. of the Unguentum Hydrargyri. The prescriber should note that "Blue Ointment" now means the diluted mercurial ointment, and not (as formerly) mercurial ointment.

Mercurial ointment is of analogous color to mercurial pill mass—a dull indigo slowly darkening with time. By far the greater quantity of the mercury contained in this ointment is in simple mechanical subdivision, but yet a certain small proportion has probably become converted into mercurous oxide, and this in turn has reacted upon the lard, or upon certain products of the decomposition thereof. And to these undetermined secondary compounds some are disposed to ascribe the medicinal activity of the ointment.

Mercurial ointments do not irritate the sound skin unless rubbed in, and that, too, repeatedly at the same spot. Medicinally, they fulfil, mildly, the local therapeutics of mercurials, and also—their most valuable property—when applied by inunction, gain entrance in some way to the general circulation and mercurialize the whole system rapidly, thoroughly, and, because of the avenue of access, with a minimum of disturbance of stomach and bowels. Just how and in what chemical combination the mercury enters the blood in such case has been a subject of much speculation and theory, but the matter is still unsettled and is one of no practical bearing. The uses of mercurial ointments are for the purely local purposes of mercurial applications generally, to destroy parasites, or to set up healthy action in sores, eruptions, or glandular indurations not far below the skin surface, and also to mercurialize in syphilis, especially when speedy and thorough action is wanted. For simply local effects, the ointment is applied in the common way, but to mercurialize the system at large a special procedure is requisite, of which the point is that the preparation is to be rubbed thoroughly into the skin, until absorption of the mercury takes place through the tissue of the same. To insure speedy absorption, the application is made where the skin is thin and without much underlying fat, as is the case on the inner aspect of the upper arm or the thigh and on the sides of the trunk. At least four, and, better, six sites should be used in succession, in order to save the irritation that follows too frequent inunction upon one spot. The proceeding is as follows: At night the selected site is well cleansed with soap and water, and dried. Then, preferably before a fire, weather and circumstances favoring, the quantity of from two to four grams (℥ss.–i.), according to the urgency of the case, is rubbed in until the ointment has apparently disappeared. The part is then bound up in flannel, and is not washed until the following morning. This maneuver is repeated nightly, or, possibly, even twice a day, until either the desired therapeutic effect is obtained, or until beginning of soreness of the gums enforces discontinuance. One or the other result is commonly attained inside of a week. If the patient require to have the inunction done by somebody else, the hand of the rubber must be protected by a glove of caoutchouc or other device to guard against self-mercurialization. In the case of infants a piece of the ointment of the size of a pea may simply be smeared upon the skin of the axilla, or of the popliteal space. The ceaseless natural motions of the child then suffice for the rubbing.

Emplastrum Hydrargyri, Mercurial Plaster. Metallic mercury is triturated to extinguishment with a small quantity of the pharmacopœial oleate of mercury and the product then mixed thoroughly with melted lead plaster. The resulting plaster contains thirty per cent. of mercury, and possesses to a slight degree the local specific virtue of mercurials, in addition to the usual properties of plasters.

Mercurous Compounds.—The series of mercurous salts which come next for discussion are all insoluble in water and, accordingly, are locally bland. Internally, in single full dose, they are purgative; in small repeated dose they mercurialize rapidly, with especial tendency to produce the specific features of salivation, in the restricted sense of the word.

Mercurous Chloride, HgCl.—Mercurous Chloride is official in the United States Pharmacopœia under the title *Hydrargyri Chloridum Mite*, Mild Mercurous Chloride. It is also known, in the terms of a former chemical nomenclature, as *subchloride* or *protochloride* of mercury, and, more commonly yet, in the vernacular, as *calomel*. Calomel is bought by the dispensing pharmacist from the large-scale manufacturer, its preparation—to be done well—requiring special apparatus. The principle of the process ordinarily followed is to subject to sublimation a mixture of mercury, mercuric sulphate, and sodium chloride. By a preliminary trituration of the mercury and mercuric sulphate mercurous sulphate forms, and, upon heating, this mercurous sulphate exchanges acid radicals with the sodium chloride, with the forming of mercurous chloride and sodium sulphate. The calomel sublimes, and, according to different methods of preparing, condenses either in a crystalline cake or as an impalpable fine powder. If obtained in cake, this requires pulverization in order to submit the calomel to a thorough washing with water, for the removal of traces of mercuric chloride that form along with the calomel. If condensed as powder, it is through the agency of steam (Jewell's or Howard's process), which, as it determines condensation, also very thoroughly accomplishes the necessary washing. Calomel made by the latter process is the most esteemed, and can be distinguished by its snowy whiteness, as compared

with the yellowish tint of calomel obtained by the other method.

Calomel is a white, impalpable powder, permanent in the air, odorless and tasteless, and insoluble in water, alcohol, or ether. When strongly heated, it is wholly volatilized, without melting. The most dangerous impurity to which calomel is liable is corrosive sublimate (mercuric chloride), for which the test is to wash the calomel with warm distilled water, and then add to the washings some water of ammonia. If any corrosive sublimate have been dissolved by the washing, a white precipitate (ammonio-chloride) will now fall. Also, there may be contamination with this same ammonio-chloride. To detect this, shake the calomel with acetic acid, filter, and treat the filtrate with hydrogen sulphide, and with solution of silver nitrate. Coloration by the one and the forming of a white precipitate with the other indicate the presence of the ammonio-chloride. Other likely impurities are not dangerous.

The reactions of calomel that have a bearing, real or fancied, upon its medicinal employment, are first, that free bases decompose the compound with the formation of mercurous oxide, and secondly, that ammonium chloride, and to lesser degree potassium and sodium chloride, in sufficient concentration and at a proper elevation of temperature, tend gradually to convert the mercurous into the mercuric chloride—to change, that is, calomel into corrosive sublimate. Great stress has been laid upon the latter reaction. It has been made to do duty in accounting for all the medicinal activity of calomel, the same being ascribed to the corrosive sublimate into which the calomel is assumed to be changed by the alkaline chlorides present in the contents of stomach or bowels; and for fear of undue rapidity and completeness of such conversion, the taking of common salt during a course of calomel medication has often been proscribed. On the other hand, it is asserted that the degree of concentration of the alkaline chlorides commonly occurring in the alimentary canal, and the temperature therein, are inadequate to any but a trivial production of the reaction in question. Pending the definite settlement of the question, it is just as well to avoid the joint taking, in any marked quantity, of calomel and ammonium chloride, or even of calomel and either potassium or sodium chloride. Other substances alleged to have the power of converting calomel into corrosive sublimate, are *hydrocyanic acid*, *citric acid*, and *sugars*. Of these substances the first never needs to be prescribed with calomel, and the averred potency of the other two is far from established.

Locally the action of calomel is absolutely bland, so long as the salt preserves its integrity, but, after swallowing, effects, local or constitutional according to circumstances of administration, declare themselves—which effects, because of the great insolubility of calomel, must be ascribed to some as yet undetermined compound into which calomel is changed in its course along the alimentary canal. The effects differ profoundly, according to whether the medicine is taken in single full dose, or in small repeated doses continued for some days. In the former case, with or without nausea, according to size of dose and sensitiveness of the stomach, and with or without griping, as the case may be, there follows, in about eight hours or so, a call to stool, and mucous passages, brown, yellow, or even green in color, result—green stools being particularly common in the case of children. Such purging, if free, commonly constitutes the whole outcome of the dose; but if not free, constitutional symptoms, showing absorption of the mineral, may follow. The marked coloring of calomel stools has for years been held to be due to an unusual proportion of bile therein contained, and though this has been denied, yet some chemical analyses, as well as many clinical considerations, make it strongly probable that the venerable assumption is correct. In explanation of the considerable charge of bile in calomel evacuations, many theories have been propounded. The oldest is that excess of bile *excreted* must mean excess *secreted*, and therefore it must be taken for granted that calomel in purgative dose in some way stimulates the liver to increased secretion of bile. But against this theory is arrayed an observation that on dosing with calomel animals upon whom a biliary fistula had been established, there was no increase in the amount of bile discharged through the fistula. In rebuttal, however, it is pointed out that the very fact of the establishment of a biliary fistula so changes the ordinary condition of things *in re* liver, bile, and bile's normal intestinal career, that the experiments go for nothing. Apart from this controversy, another theory of the biliary stools following a calomel purge is that they result as a natural consequence of an assumed action of calomel in rushing down, as it were, the contents of the duodenum, and so preventing that reabsorption of a considerable portion of the bile present in the intestinal contents which is claimed to be a normal occurrence. The latter theory certainly accounts more readily than the former for the well-known corrective effects of calomel purging in so-called biliousness; but both theories are theories yet, and neither is essential to the intelligent clinical use of calomel in the condition in question. Another theory of calomel stools accepts the fistula experimentation as proving that there is no increased flow of bile, and accounts for the bile coloration by assuming that the mercurial prevents the normal development of the microbes that ordinarily determine decomposition of the bile pigment in the intestine.

In small repeated dose calomel mercurializes speedily, but in so doing is especially prone to salivate, and also, even in small dosage, to relax the bowels.

Calomel may quell vomiting, and has the advantage for such purpose that, once swallowed in the condition of powder, it is difficult to dislodge, and so may continue its action despite an occurrence of vomiting shortly after the taking. Calomel may, and commonly does, dissipate readily the symptoms of that digestive disorder called, rather vaguely, "biliousness," particularly when constipation is associated with clay-colored stools. It may also prove an efficient anthelmintic. Locally, calomel is among the standard remedies for the relief of itching.

The *therapeutics* of calomel consist in the above-described applications. As a purge, the dose for an adult is from 0.30 to 0.60 gram (from about gr. v.–x.), given at night, and followed in the morning, if purging do not sooner occur, by some brisk cathartic, such as a dose of salts. Very often, instead of being given alone, calomel is associated with some other purgative such as jalap, in which case its dose must be reduced proportionally. As a corrective in bowel disorders not requiring purging, calomel may be given in centigram doses (one-sixth of a grain), or less, hourly throughout a single day; yet it may be noted that sometimes this method of dosage results in free purging—as free as if a full cathartic dose had been taken. For anthelmintic purposes, full purgative doses are to be given. To mercurialize, from 0.10 to 0.20 gram (about gr. ij.) should be prescribed to be consumed daily, divided into at least four doses, and the laxative tendency neutralized by a trifle of opium with each dose. Careful watch should be kept for possible salivation, and the medication discontinued, or the dose reduced, at the first signs of soreness of the gums. Calomel may be administered in powder or pill. Externally, for the relief of itching, calomel is best prescribed in extemporaneous ointment, of ten-per-cent. strength.

A special application of calomel is to mercurialize by the process of *fumigation*, so called. This process is based on the fact that calomel sublimes without change, and that when so sublimed and allowed to condense on the naked moist skin, in some way it rapidly gains access to the general circulation, and so

mercurializes with great promptness and certainty. At the same time, because of the avenue of introduction, the digestive organs are not deranged. Under circumstances, therefore, where there is a call for both a prompt and powerful mercurial impression, as in some sudden and severe syphilitic inflammation, the method by fumigation is a thoroughly reliable one. The objections to the method are its troublesomeness, and the exposure of the patient to detection of his malady—objections which, while often annoying, should not condemn the use of the method if the necessity be serious. The process is as follows: By any convenient arrangement—as by laying upon a bit of sheet metal properly supported—the quantity of from two to four grams (from gr. xxx.–℥ i.) of calomel is exposed to the heat of an alcohol lamp, while at the same time a small vessel of water, such as the tin cup of a nursery lamp, is set to boil alongside. These contrivances are arranged under a chair, and upon this chair the patient is seated, naked, and covered, all but the head, by a blanket reaching to the ground. The blanket is to be clasped tightly about the neck to prevent the mercurial fumes from rising about the face, in which case they might be inhaled. By this arrangement a small confined chamber is made, within which all the patient's body, excepting the head, is exposed to the combined action of steam and subliming calomel. Free perspiration is soon induced, and in the moist, relaxed condition of the skin thus brought about, the calomel, condensing upon the surface, finds easy access to the circulation. The sitting lasts from ten to twenty minutes, or until all the calomel has disappeared from the metal plate, and then the patient, donning his night-dress without washing, gets into a warm bed for the night. In the morning a bath may be taken. Such fumigations may be made every other day, or, in urgent cases, daily, until the gums begin to show signs of soreness.

Calomel is an ingredient of the pharmacopœial *compound cathartic pills* (see *Colocynth*).

Mercurous Iodide, HgI.—Mercurous iodide, the *subiodide* or *protoiodide* of the old chemistry, is official in the United States Pharmacopœia under the title *Hydrargyri Iodidum Flavum*, Yellow Mercurous Iodide. The salt is formed by double decomposition, by adding a solution, in water, of potassium iodide to one of mercurous nitrate. Prepared in this way, mercurous iodide appears as a bright yellow powder. It is without odor or taste; is nearly insoluble in water and wholly so in alcohol or ether. It was formerly prepared by direct union of its elements, and then was of a greenish-yellow color and was known as the "green" iodide. Mercurous iodide is slowly decomposed, by light, into metallic mercury and mercuric iodide, and accordingly should be kept in dark amber-colored vials, and away from light.

The action of mercurous iodide is closely similar to that of calomel, and in the doses of it possible in medicine, the iodine it contains is in too small proportion to exert any appreciable degree of its peculiar influence. Mercurous iodide, therefore, like most of the iodides of the heavy metals, is practically but a representative of the medicinal virtues of the metal. Mercurous iodide is used exclusively as a means of mercurializing by the mouth, and is a favorite preparation with many practitioners in the mercurial treatment of syphilis. The quantity of from 0.06 to 0.20 gram is to be given daily, in divided doses, with due watch kept on the gums. The medicine is most conveniently given in pill, and the important incompatibility must be remembered that potassium iodide decomposes this salt, producing metallic mercury, and the far more potent *mercuric* iodide.

Mercuric Compounds.—Mercuric Oxide, HgO. Mercuric oxide is obtainable in two ways, namely, by decomposing a nitrate of mercury by strong heat, or by precipitating a solution of mercuric chloride by solution of soda. The respective products of these two processes, though identical chemically, differ in their physical features, and both are official in the United States Pharmacopœia under distinctive names, as follows:

Hydrargyri Oxidum Rubrum, Red Mercuric Oxide, "Red Precipitate." This is the oxide made by the former of the processes described above. The preparation is nearly pure oxide, but with a trace of undecomposed nitrate still present. It appears as a heavy crystalline powder of a brilliant, orange-red color, which becomes more yellowish the finer the powder is divided. It is permanent in the air, odorless and tasteless, insoluble in water or alcohol, but wholly soluble in nitric or hydrochloric acid. By heating, it is decomposed into oxygen and metallic mercury, and finally volatilizes without residue.

Hydrargyri Oxidum Flavum, Yellow Mercuric Oxide. The oxide obtained by precipitation as described above. This form of mercuric oxide is a fine, amorphous powder, of a light orange-yellow color, darkening on exposure to light. Its solubilities are the same as in the case of the red oxide. On heating, it first turns red and then behaves the same as the red oxide.

Both varieties of mercuric oxide should be kept in well-stoppered bottles, away from exposure to light.

Mercuric oxide, despite its insolubility, is, like all the mercuric compounds, decidedly irritant, enough so to produce dangerous irritant poisoning if swallowed in overdose. Yet, compared with the other mercuric compounds used in medicine, it is less harsh than the majority. Of the two forms of this oxide, the red is the more irritating because of the mechanical action of the sharp-edged crystalline grains of which it is composed.

Mercuric oxide is used exclusively as a local medicine, to obtain the specific mercurial irritant influence in affections of the skin or of exposed mucous membranes. It is most commonly employed in one or other of the two official ointments: *Unguentum Hydrargyri Oxidi Rubri*, Ointment of Red Mercuric Oxide, and *Unguentum Hydrargyri Oxidi Flavi*, Ointment of Yellow Mercuric Oxide. Both ointments are of similar composition—ten per cent. of the mercurial thoroughly incorporated with hydrous wool fat and petrolatum. The yellow oxide is also much used in the form of lotion, consisting of the compound suspended in water. This unofficial lotion is commonly called *yellow wash*, and is obtained by mixing together two grams (gr. xxx.) of mercuric chloride and 500 grams (1 pint) of lime water. As in the case of the so-called *black wash* made from calomel, the mercurial chloride is decomposed by the lime and the oxide precipitated. Yellow wash is more irritant than black wash.

Mercuric Chloride, $HgCl_2$. Mercuric chloride, formerly known as *bichloride* or *perchloride* of mercury, is official in the United States Pharmacopœia under the title *Hydrargyri Chloridum Corrosivum*, Corrosive Mercuric Chloride, and is universally known by the familiar name *corrosive sublimate*, or simply *sublimate*. The salt is made on the large scale by subliming a mixture of mercuric sulphate and sodium chloride, and is bought by the pharmacist from the manufacturer. Mercuric chloride is a colorless salt, permanent in the air, and occurring in rhombic crystals or crystalline masses. It is odorless, but has an acrid and persistent metallic taste. It dissolves in 16 parts of water at ordinary temperatures and in 2 parts of boiling water; in 3 parts of cold alcohol and in 1.2 parts of boiling alcohol; in 4 parts of ether and in about 14 parts of glycerin. On heating, it fuses, first, to a colorless liquid and finally volatilizes in dense, white fumes and leaves no residue. The most important contamination of corrosive sublimate is by arsenic, a test for which is the following, quoted from the United States Pharmacopœia of 1880: "If 1 gm. of the salt be dissolved in boiling water, then mixed with 5 c.c. of strong solution of soda (sp. gr. about 1.260) in a long test-tube, and about 0.5 gm. of fine

aluminum wire, cut into small pieces, be added (a loose plug of cotton being pushed a short distance down the tube, the generated gas should not impart any tint to paper wet with test solution of nitrate of silver,* and kept over the mouth of the test-tube for half an hour (absence of arsenic)." Calomel may be another adulteration, easily detected by its non-solubility in water or alcohol; and all other likely contaminating substances will reveal themselves by non-volatility on subjecting the suspected sample of mercuric chloride to sublimation. Corrosive sublimate should be kept in well-stoppered bottles.

The reactions of corrosive sublimate that are important to the prescriber are as follows: The salt forms double salts with ammonium and with sodium chlorides, which double salts are of the same physiological potency as the simple sublimate, but, differing from the simple salt, dissolve very freely indeed in water. Practically, therefore, any desired concentration of aqueous solution of corrosive sublimate can be effected by simply adding sal ammoniac or common salt to such aqueous mixture. Next, corrosive sublimate in aqueous solution *decomposes* by the following agencies: Simple keeping under exposure to light, whereupon calomel and hydrochloric acid separate out; or the addition to the solution of any of the following substances, viz., alkalies or their carbonates, the alkaline earths, soap, tartar emetic, silver nitrate, lead acetates, potassic or sodic sulphides, sulphydrates, soluble iodides, and many animal and vegetable substances. Mercuric chloride, thus, has a wide range of incompatibility.

In its action, mercuric chloride is intensely inimical to life of all varieties and grades, and so operates as a powerful antiseptic. Tissues immersed in a sublimate solution become tough and shrunken, whitish in color, and proof against putrefaction. On the living human system the salt combines the properties of an active mercurial with those of an intense irritant. In concentrated application it is even caustic, but it is not astringent. Taken internally in small, repeated dosage, corrosive sublimate mercurializes, and with a minimum of salivation. But it is very prone to disorder the stomach, producing epigastric uneasiness and soreness, with loss of appetite and even nausea. In comparatively small overdose, the salt is a dangerous poison, and is one of the things most commonly used for poisoning purposes. (For Toxicology, see next article.)

Medicinally, corrosive sublimate is used both externally and internally. Externally, it is applied most commonly in solution, for the destruction of parasites, or for the specific influence of mercury, when a sharp impression is wanted upon skin eruptions, or, again, as an antiseptic in the treatment of wounds. Sublimate lotions may be aqueous or alcoholic, but should not exceed the strength of one-half of one per cent. of the mercurial in solution, lest undue irritation, or even, in extensive application, absorption and poisoning result. As an antiseptic, mercuric chloride is unrivalled in power, experimental research showing that 1 part in 20,000 is the germicidal peer of 1 part in 833 of the next most potent agent. This potency makes the salt available for efficient antisepsis in the treatment of wounds, in solutions of non-irritant and non-poisonous strength. A solution of one-tenth per cent. is used for the wetting of sponges, compresses, and absorbent dressings, a strength of one-quarter per cent. for the gauze, and a strength of one per cent. for silk sutures or catgut. Internally, frequently repeated minute doses of corrosive sublimate, such as 0.001 gm. (about gr. $\frac{1}{60}$) are often of happiest effect in bowel derangements with fermentation of the food. Such small doses are commonly given in simple aqueous solution. To mercurialize, the average dose is 0.004 gm. (gr. $\frac{1}{15}$) three times a day, in solution or in pill with crumb of bread—the pill mass to be made up with particularly thorough trituration. Mercurialization thus induced is not very speedy, and, since the drug is too poisonous ever to be pushed, it is not an eligible mercurial in cases calling for haste. And under any circumstances, the tendency to irritate the stomach is so great that, for constitutional mercurializing, corrosive sublimate is distinctly not desirable. The salt has also been given by hypodermatic injection for treatment of syphilis, about 0.005 gm. (gr. $\frac{1}{12}$) being injected every other day in aqueous solution. But the procedure is objectionable because severely painful.

*Five-per-cent. solution in distilled water.

Mercuric Iodide, HgI_2. Mercuric iodide—"biniodide," "periodide"—is official in the United States Pharmacopœia under the title *Hydrargyri Iodidum Rubrum*, Red Mercuric Iodide. The salt forms by double decomposition on mixing, in solution, mercuric chloride and potassium iodide, and falls as a scarlet precipitate. Collected and dried, it appears as an amorphous powder, permanent in the air; of a bright scarlet color; odorless, tasteless, and insoluble in water. It dissolves in 130 parts of cold alcohol and in 15 parts of boiling alcohol; also in solution of potassium iodide or of mercuric chloride. On heating it turns yellow, then fuses, and finally volatilizes without residue. It should be kept in well-stoppered bottles, away from light. Mercuric iodide may be contaminated by a little undecomposed mercuric chloride or potassium iodide, whose presence can be detected by washing the sample with water, filtering, and testing the filtrate with a five-per-cent. aqueous solution of silver nitrate. Any soluble iodide or chloride will then precipitate the silver. The most important reaction of mercuric iodide is that it forms double salts with the iodides of the alkalies, which salts dissolve freely in water, yielding colorless solutions. This reaction will take place in the official process for making mercuric iodide, if the potassium iodide be taken in excess, the scarlet precipitate that falls on adding the solution of mercuric chloride instantly redissolving on slight agitation, giving, in colorless solution, the potassium double salt. This same potassio-mercuric iodide, under the name of *iodohydrargyrate of potassium*, has been used in medicine, with the claim for it of remarkable powers, but its effects are substantially those of the simple mercuric iodide—just as a solution of the salt itself is substantially but a solution of mercuric iodide in excess of potassium iodide. The physiological properties of mercuric iodide are practically identical with those of the chloride—locally irritant even to corrosiveness, constitutionally mercurializing in the manner just detailed under mercuric chloride. The salt is not much used, yet some practitioners are partial to it for the purposes of a constitutional mercurial, the administration being in doses and with observances identical with those employed in the giving of mercuric chloride. The iodide may be given in pill, or in solution of potassium iodide. If wanted in the latter way, it may be obtained by prescribing an equivalent quantity of mercuric *chloride* to be added to a solution of *potassium iodide*. By reaction red iodide then forms and remains in solution as double salt, in the manner set forth above.

Mercuric iodide is an ingredient of the official preparation entitled *Liquor Arsenii et Hydrargyri Iodidi*, for whose discussion see under Arsenic.

Mercuric Nitrate, $Hg(NO_3)_2$.—Mercuric nitrate is used medicinally only in the two following pharmaceutical preparations:

Liquor Hydrargyri Nitratis, Solution of Mercuric Nitrate "Acid Nitrate of Mercury." Red mercuric oxide is dissolved in excess of dilute nitric acid, whence results a dense, clear, nearly colorless, strongly acid liquid, of specific gravity 2.100, and containing in solution about sixty per cent. of mercuric nitrate together with about eleven per cent. of free nitric acid. This liquid is highly corrosive, and is used solely as a searching caustic. It is applied to the part in full

strength, and should be used only when a rather spreading action is allowable or desirable.

Unguentum Hydrargyri Nitratis, Ointment of Mercuric Nitrate, Citrine Ointment. This contains seven per cent. of mercury; and is a yellow ointment, decidedly irritant, and exerting powerfully the local specific medicinal powers of the mercuric compounds. Citrine ointment is thus available to destroy parasites, or to excite a healing action in indolent ulcers or eruptions. Unless a strong effect is needed, the ointment should be diluted with lard in equal parts.

Mercuric Oleate.—Formula of normal oleate, $Hg(C_{18}H_{33}O_2)_2$. The only condition in which an oleate of mercury is official in the United States Pharmacopœia is in the preparation entitled *Oleatum Hydrargyri*, Oleate of Mercury. The quantity of twenty-five per cent. of dried yellow mercuric oxide is dissolved in oleic acid. If made with oleic acid of standard quality the product is a transparent, yellowish, oily liquid; but if an impure commercial acid be the basis, it is a soft semisolid. The preparation is liable to undergo slow change with deposition of metallic mercury, but the better the quality of the oleic acid used in the making, the slower the decomposition. Its properties are those of a moderately irritant mercuric salt, made highly diffusible by the peculiar attributes of oleic acid. Rubbed into the skin, the mercurial is absorbed as in the similar application of mercurial sintment, but more rapidly and thoroughly. Constitutional mercurialization is thus easily procurable. Lightly brushed upon a part, the preparation produces the local mercurial effects, and, because of its diffusibility, acts more thoroughly than do ordinary ointments or aqueous lotions. For destroying the vitality of the ova of lice, or of vegetable parasitic organisms, the preparation is unsurpassed. To produce constitutional mercurialization, the oleate is used in the same way as mercurial ointment. For such application the oleate is superior to the latter preparation in speed, effectiveness, and cleanliness; but being more irritant, it is liable to make the skin sore or even to raise an eruption. To neutralize this tendency so far as possible, a good plan is to order one per cent. of morphine—the pure alkaloid—to be dissolved by gentle heat in the oleate. For local effects the oleate of mercury is lightly applied to the part by a camel's-hair brush, and, if the skin be tender, morphine may be added, as just described. Oleate of mercury is contained in Unguentum Hydrargyri and Emplastrum Hydrargyri.

Besides the foregoing official preparations, numerous others have been proposed, of which the more important are the following:

Mercurous Tannate.—This salt forms by the action of tannic acid upon mercurous nitrate. It is of a greenish color, and resembles calomel in being insoluble in water or alcohol, and, accordingly, odorless, tasteless, and bland in local action. Its peculiarity is that it is easily decomposed by alkalies, however weak, and in such decomposition yields metallic mercury in exquisitely fine subdivision. Accordingly, when swallowed, it is decomposed by the alkaline contents of the duodenum, and offers mercury in a condition ready for absorption but yet not irritating. The tannate, therefore, is a possible bland mercurial for constitutional use, and may be prescribed as an antisyphilitic in doses of 0.06 gram (gr. i.), in pill. The salt is incompatible with even the weakest of alkalies. Also, potassium iodide should not be given in conjunction.

Mercurous Bromide is a white, insoluble compound, for practical purposes a duplicate of calomel.

Mercuric Bromide is similarly a duplicate of corrosive sublimate. The bromides may be used in the same way as the corresponding chlorides, but present no advantages.

Mercuric Salicylate is a mercury preparation of salicylic acid in which one atom of mercury has combined with one molecule of salicylic acid. It is an amorphous, white powder, insoluble in water or alcohol, and accordingly without odor or taste. It dissolves in solution of any of the alkaline chlorides, bromides, or iodides, such as, for instance, common salt. The salt has been proposed for internal giving as a constitutional mercurial, on the ground of being effective while but little disturbing to the digestive organs. It may be given in doses of 0.01 gram (gr. $\frac{1}{6}$), in pill. Also it has been used as an antisyphilitic, by injection, hypodermatic or intramuscular, the powder being suspended in mucilage or paraffin oil. The mixture must be well shaken before use, and 0.01 gram (gr. $\frac{1}{6}$) may be given at each injection.

Calomelol, or colloidal calomel, is used in much the same way as calomel, which it resembles in action. The colloidal action is said to make it less irritant and less toxic than calomel.

Mercuric Oxycyanide has been suggested as a substitute for corrosive sublimate; it is claimed that the oxycyanide is less irritating and more antiseptic than the bichloride. It does not corrode steel instruments.

Mercuric Succinimide has the action of mercurial salts in general, but is said to be non-irritating. It is used in cases of syphilis.

Mercurol or mercury *nucleinate* is an organic compound of mercury with nucleinic acid, and contains ten per cent. of metallic mercury. It is used as an antisyphilitic.

Sublamine is mercuric sulphate ethylene diamine; it is a disinfectant, similar to corrosive sublimate but less irritating and more penetrating and soluble. It is used as a disinfectant for the hands, and also in gynecology, and eye and ear work.

Other preparations, proposed especially for hypodermatic use in syphilis, are as follows:

Mercuric Formamidate.—A salt soluble in water, neutral in reaction, non-coagulating to albumin, and giving but little pain on injection. Dose for injection, from ten to twenty drops of a one-per-cent. aqueous solution.

Mercuric Benzoate.—A white, crystalline salt, without odor or taste. Sparingly soluble in cold water, but soluble in hot water, in alcohol, and in an aqueous solution of common salt. Three parts of the benzoate and one part of common salt may be dissolved together in four hundred parts of water, and of this solution one (hypodermatic) syringeful may be injected daily.

Mercury Amidopropionate or *Alanate.*—A white, crystalline powder, soluble in water. From 0.005 to 0.01 gram (gr. $\frac{1}{12}$–$\frac{1}{6}$) may be given at each injection, in aqueous solution.

Mercury Sozoiodol.—A fine, yellow powder, sparingly soluble, only, in water (1 part in 500) but soluble in solution of common salt. Dose for hypodermatic injection, 0.06 gram (gr. i.). In strong solution, the compound is irritating. It is also employable locally, as a dusting powder, or in ointment of one or two per cent. strength.

Mercury Imidosuccinate, or *Asparaginate.*—A white, crystalline powder, soluble in 25 parts of water and in 300 parts of alcohol. Dose, by injection, 0.01 gram (gr. $\frac{1}{6}$).

For local use, the following have been proposed:

Mercury Pyroborate.—An amorphous, insoluble brown powder. Used in ointment (two-per-cent. strength) as a dressing for syphilitic or other sores.

Mercury Stearate.—A white, unctuous powder, for use as a dressing in place of ointment preparations.

Mercury-zinc Cyanide.—A white powder, insoluble in water. Recommended by Lister for use in antiseptic dressings. Its insolubility saves it from irritating and poisoning.

Compounds of mercury formerly official in the United States Pharmacopœia, and still occasionally used, are as follows:

Mercurous Oxide, Hg_2O.—This is the compound commonly called *black oxide* of mercury. It is a dingy, dark olive powder, insoluble in water or alcohol. Its only use is in the so-called *black wash*, a mild mercurial lotion for syphilitic sores. This wash is practically mercurous oxide diffused through water. To obtain it, calomel is mixed with lime water, generally in the proportion of four grams (ʒ i.) of the former to 500 grams (O i.) of the latter. Reaction occurs, the lime abstracting the chlorine from the calomel to form calcium chloride, which remains in solution, and giving oxygen in exchange, so that the white powder of the mercurous chloride changes to the dusky one of the oxide. On standing, the precipitate of the oxide rapidly settles to the bottom of the vessel containing the wash, so that the mixture needs to be shaken well before using.

Mercuric Sulphide, HgS. This is the well-known substance *cinnabar*, which, finely powdered, makes the pigment *vermilion*. It is a bright red substance, permanent, odorless and tasteless and insoluble in water or alcohol. It was formerly used for mercurial fumigation, by the plan of throwing about two grams (gr. xxx.) on hot coals so placed that the resulting fumes should bathe the naked body of the patient, under an enveloping blanket. But the procedure develops sulphur dioxide gas which is highly irritating.

Cinnabar, accordingly, is now discarded, for use in fumigation, in favor of calomel.

Mercurous Sulphide, Hg_2S. This compound, long since abandoned as a medicine, needs mention only as being the mercurial formerly called the *black sulphide*, or *Ethiops mineral*.

III. General Therapeutics of Mercury Compounds.—As has appeared in the discussion of the several compounds of mercury, the therapeutic uses of the mineral are many and incongruous. Some of these are fulfilled by a single preparation only, but others, and the majority, are possible for several of the compounds. Concerning these latter some practical points present themselves for consideration.

Constitutional Mercurialization.—This procedure was formerly resorted to, in a routine way, in all cases of acute inflammations, especially of serous membranes, generally also in the continued fevers, and, in mild grade, in the various cachexiæ. Nowadays, however, it has fallen into disuse, except in the treatment of the single disease syphilis. In this affection its avail is most important, as will be found discussed in the article on *Syphilis*. General mercurialization can be effected by giving mercurials by the *mouth*, by *inunction*, by *fumigation*, and by *hypodermatic injection*. In general concerning these methods, the points may be noted that administration by the *mouth* is most convenient, is reasonably prompt and efficient, except in cases of most urgent haste, but subjects the digestive organs to a maximum of derangement. The *inunction* method is rapid and potent, peculiarly applicable therefore to urgent cases; saves the digestive organs, but is troublesome, dirty, and exposes the patient to detection of his malady. The *fumigation* process has all the features of the inunction method, with an extreme of troublesomeness. The *hypodermatic* procedure also is prompt, powerful, and saving to the digestive organs, but, with the preparation hitherto most used for the injection, corrosive sublimate, has the profound objection of being painful, and liable to produce abscess. To mercurialize by the *mouth*, if the object be a long-continued, gentle impression, mercury with chalk or blue mass, or small doses of the yellow iodide, are commonly selected from among the mild mercurials. For a less continuous action, but one still short of full therapeutic saturation, the *mercuric* compounds, chloride, or iodide, may be employed. Between the respective action of the two groups, the important points of difference are that the *mild* mercurials are most apt to salivate and provoke looseness of the bowels; and the *irritant* unduly to irritate the stomach. For the rapid production of the full limit of mercurialization by the mouth, the more potent of the mild mercurials—calomel, blue pill, or the yellow iodide—should be given in generous dosage. For rapid effect, however, mercurialization by other avenue than the mouth is theoretically preferable. For *inunction*, mercurial ointment and the oleate are the two available preparations, of which the latter is the more elegant and cleanly, but also the more irritating. For *fumigation*, calomel, and the black oxide are possible, but the first named is decidedly to be preferred. For *hypodermic injection*, corrosive sublimate has been the preparation most used. By any method and for any purpose, modern practice enjoins that mercurialization must be limited in degree to the development of the mildest grade of stomatitis.

Digestive Disorders.—The correction of digestive disorders is one of the prominent applications of mercurials. The efficacy is one of wide range, and in it the antiseptic virtues of mercury probably play a part. The derangement in which the mineral has the oldest reputation is that whereof the main symptoms are constipation, with clay-colored stools, loss of appetite, with a bitter taste in the mouth, and perhaps even nausea, and a muddy or even distinctly jaundiced skin and conjunctiva. In such condition of things, as soon as a free passage from the bowels can be secured by a mercurial—calomel or blue pill, or, in the case of children, mercury with chalk—the various symptoms very commonly subside. And even if there be not constipation, mercury, now not necessarily in purgative dose, will still more often than not work a cure. Next, entirely apart from the matter of clay-colored stools, many cases of vomiting from digestive disorders, and, still more commonly, diarrheal or dysenteric symptoms arising apparently from the same cause, are more or less controllable by mercurials. The selection is commonly calomel or mercury with chalk for vomiting, and mercury with chalk or corrosive sublimate for bowel affections. In all cases the dose is small, as, for instance, 0.01 gram (gr. $\frac{1}{6}$) of gray powder, or 0.001 gram (gr. $\frac{1}{60}$) of corrosive sublimate, frequently repeated.

The Killing of Parasites.—A purgative dose of calomel is anthelmintic, but it is particularly for the destruction of external parasites that mercury is used, a purpose for which mercurials are pre-eminent. The forms selected are usually corrosive sublimate in solution, white precipitate ointment, citrine ointment, mercurial ointment, or the oleate. The last named is the preparation to be preferred where the ova of lice are to be destroyed.

The Treatment of Skin Affections.—The surface disorders of syphilis are treated with great advantage by mercurials, locally applied, as an adjunct to constitutional treatment; but also non-syphilitic skin affections are often benefited by the same measures. Recognizing that the applications are irritant, the principle obtains to graduate the irritation of the application to the irritability of the part—a raw surface, tender and painful, taking a mild application, and an unbroken skin or an indolent ulcer a comparatively harsh one. In the order of their intensity of action, beginning with the mildest, the preparations in common use as local applications are as follows: *Calomel*, applied as powder or in ointment; *black oxide*, in the form of black wash; *mercurial ointment; ointment of the yellow oxide; ointment of the red oxide*; *ointment of ammoniated mercury; oleate; ointment of the nitrate;* lotions of *corrosive sublimate*.

The other prominent therapeutic uses of mercurials are generally unique, and the points concerning them have already been discussed in connection with the individual preparations.

Edward Curtis.
R. J. E. Scott.

Hydrargyrum, Poisoning by.—All compounds of this element are violent poisons to all organisms whether plants or animals. Even in its elemental state metallic mercury is, under certain conditions, extremely poisonous.

The severity of the symptoms and rapidity of action in each individual case will depend upon the nature of the compound absorbed, the method of administration, size and frequency of the doses taken, and the susceptibility of the victim; conditions which are of general application to all poisonings.

According to statistics collected by Kobert, ninety per cent. of the cases of poisoning by mercury are due to its administration in some form by physicians; the drug having been administered in too large a quantity at a single dose, or its use having been continued for too long a period of time or, finally, there having been careless or excessive use of corrosive sublimate in antiseptic surgery. Criminal poisonings form about one per cent. or less of the cases recorded; while attempted suicide by means of mercurial products will claim about two per cent.

Quite recently the attention of the public has been focussed through a sensational press, upon cases of accidental poisoning by bichloride of mercury tablets, and much has been made of the few cases by excitable physicians with, however, good results in that drastic laws regulating the sale of this and other dangerous drugs have been enacted in several States. Available statistics do not show, however, that there has been any greater proportion of deaths from mercury poisoning than given above.

In the ordinary practice of a physician, poisoning from the following compounds of mercury may be encountered:

Metallic Mercury.—Recent researches show that mercury vaporizes at all, save exceedingly low, temperatures. Even when in the solid state (− 39.4° C.) vapor is given off. Vaporization is not, however, readily detected until the temperature has risen to about + 5° C. Poisoning through breathing the vapors of metallic mercury is not uncommon, but cases of acute poisoning are rare. As examples of extensive poisoning by vapors of metallic mercury two famous cases may be cited. The first, that of the crew of H. M. S. *Triumph*, has become classical. This frigate sailed in 1810 with a cargo of mercury. The receptacles ruptured as a result of rough weather, discharging several tons of mercury into the hold. All animal life on board suffered from mercurialism, her crew being rendered helpless. Picked up at sea, the crew of the rescuing vessel detailed to man her while being towed into port were also stricken, as were the laborers charged with cleaning her up when in port. In all 200 men were afflicted. Two died.

The other case is that related by Kumnitz, In 1802 a fire broke out in the workings of the mercury mines at Idria, and as a result of the vaporization of mercury it is estimated that over nine hundred persons were afflicted with tremor mercurialis.

In the mining of the ore about one per cent. of the workmen are attacked, while in smelting fully eight to ten per cent. suffer. These same figures will probably hold good for general industrial conditions where metallic mercury is carelessly handled and where the ventilation is poor. Even in poorly ventilated shooting galleries the attendants may exhibit symptoms of mercurialism due to mercury vapor from the exploding of mercury fulminate.

In connection with this discussion of cases of poisoning by vapors of mercury it is of interest to note that it is a quite well-established fact that persons exhibiting a tendency to phthisis are very susceptible to the action of these vapors and rarely recover from their effects, dying either from mercurialism or from tuberculosis.

The *pure* metal in the form of liquid seems to have only very slight action, often none at all. Fröhner has shown that dogs and swine can easily support doses of 250 to 500 grams (½ to 1 lb.) without exhibiting any symptoms of toxic action. Although enormous doses of metallic mercury have been swallowed by man with impunity, cases are on record where relatively small amounts have been followed by serious effects.

If the metal is taken in a finely divided condition, as, for example, emulsified in fats, oils, etc., it becomes a most violent poison. The careless use of "blue ointment," "gray oil," "blue pill," etc., has led to numberless cases of serious illness. Leibling cites the case of three persons affected with the itch who rubbed into the body a mercurial ointment containing 270 gram of finely divided metallic mercury. Death resulted in twenty-four hours from acute mercurial poisoning.

Mercuric Chloride.—This salt, known under a variety of names, of which the most common is corrosive sublimate, is responsible for by far the largest number of cases of acute poisoning by mercury. Practitioners are often too careless in the use of solutions of mercuric chloride in the dressing of wounds and in obstetrics. The fatal dose of corrosive sublimate is not well established because of the variability of the intensity of its action on different individuals. It is probably safe to set it as low as 180 milligrams (2 to 3 grains). The variability of the fatal dose and fatal period is well shown by the following case quoted by Wormley. Three children were accidentally poisoned by mercuric chloride dispensed by mistake for calomel; one, seven years old, took eighteen grains (1.16 gm.) and died in three hours; another, two years old, took six grains (0.4 gm.) and died in eleven hours; the third, aged three, took twelve grains (0.78 gm.) but did not die until the twenty-third day. Severe symptoms have followed a dose as low as from one-third to one-half of a grain. Recovery has followed such enormous doses as thirty-one grams (about ℥ i.), when there has been prompt and violent vomiting and subsequent treatment of the victim by a physician. Opium eaters are peculiarly resistant. Rigler states that a certain individual addicted to this habit was able to take 1.8 grams (gr. xxviij.) daily without illness.

In the case of so-called "bichloride tablets" employed in antiseptics we usually have to deal with a double chloride. Their toxicity is therefore much higher, they fail to respond to the usual antidotes and it is rare that the life of the victim can be saved. Death follows symptoms similar to those of uremic poisoning, as indicated below.

Mercuric Iodide produces symptoms similar in character and intensity to those of the chloride.

Mercuric Cyanide.—Very few cases of death or serious illness from mercury cyanide are on record and in several of these, the symptoms were those of hydrocyanic acid, not of mercury. Death is not, however, always rapid.

Mercurous Chloride.—Perfectly pure calomel is of very low toxicity in the case of man, but Fröhner has shown that with herbivorous animals, especially ruminants, this salt is quite poisonous: 8 to 10 grams (℥ iij.–iij.) produce very serious effects on young cattle; a dose of 20 grams (about ℥ v.) is toxic to horses; 5 grams (gr. lxxvij.) are toxic to sheep; while dogs and swine are relatively resistant the toxic dose being from 2 to 10 grams (gr. xxxi.–cliv.) per kilogram weight. Because of the ease with which calomel is acted upon by many substances, with the formation of the actively poisonous mercuric salt, accidents due to such incompatibles are not rare. There are also on record numerous cases of mercurial poisoning due to the administration of impure calomel.

Oxides of Mercury.—Mercuric oxide is met with in two forms: the yellow oxide prepared in the wet way and the red oxide prepared in the dry way. The yellow is considerably more active and more soluble

than the red. Because of its use in medicine a few accidents have resulted. In doses of about 500 milligrams (about gr. vij.) severe symptoms have been observed. The fatal dose can probably be set at from 1 to 1.5 grams. A dose of 30 grams has caused death in forty-eight hours.

Other Compounds of Mercury.—Mercur-ammonium chloride, white precipitate, is a heavy, white powder, frequently employed in medicine, and although it is practically insoluble in water it has been the cause of several cases of poisoning. Doses of from 1.9 to 2.6 grams (gr. xxx.–xl.) have produced dangerous symptoms, and 7 grams (gr. cviij.) have proved fatal in eight days.

Of the sulphates of mercury only one is of clinical interest –the *Basic Mercuric Sulphate* (Hydrargyri Subsulphas Flavus, U. S. P.). This salt, sometimes called turpeth or turbith mineral, caused the death of an adult in eleven days in a dose of 2.6 grams (gr. xl.), and in another case 3.9 grams (gr. lx.) proved fatal to a boy of sixteen in seven days.

The sulphides of mercury are so insoluble that they are sometimes said to be non-poisonous. The red sulphide, vermilion, is known, however, to have been responsible for cases of chronic poisoning in France, due to its presence in cosmetics.

Mercuric Nitrate is responsible for a number of cases of poisoning in the form of the so-called "acid nitrate," a solution of high specific gravity, formerly much employed in Europe as an escharotic. Tardieu records a case in which death resulted in about two hours after swallowing a quantity of this corrosive liquid. Most of the cases of poisoning, however, are the result of its use as an escharotic.

The *Sulphocyanate of Mercury* which serves as the basis for the manufacture of Pharaoh's serpents possesses such energetic emetic powers that there is little danger to be apprehended from its ingestion. When administered to non-vomiting animals it produces all the symptoms of mercurial poisoning. In the burning of the "serpents," vapors of metallic mercury are produced which may lead to evil results in small, ill-ventilated rooms.

Symptoms of Poisoning by Mercury.—Cases of mercury poisoning fall into one of three classes: acute, subacute, or chronic. In the first class fall all those resulting from a large dose or several rapidly taken moderate doses of a readily soluble salt of mercury; the action being that of a violent irritant poison, or of a corrosive; death taking place in from twenty-four to thirty-six hours. Subacute cases result from a somewhat slower action, the primary symptoms are not so violent and the period of illness is quite long. This second form is seen when the dose is smaller than in the first form, when small doses have been administered in too rapid succession, and when the compound taken or absorbed is not easily soluble. The fatal period varies from five to twenty days, or is often even longer; cases under eight to ten days are generally the after-result of acute poisoning. The cases classed as chronic need no explanation; they are the result of "industrial poisoning" or of medicinal posioning due to excessive prolongation of mercurial treatment. The symptoms do not appear for weeks or even months. Death may sometimes result, but recovery usually follows the removal of the cause.

Acute Poisoning.—This is generally the result of swallowing corrosive sublimate. Immediately after taking the poisonous substance there is experienced by the victim an intensely disagreeable, acrid, metallic taste followed almost at once by a burning sensation (increasing to pain) in the mouth, throat, and epigastrium; this pain rapidly extends with increasing severity to the abdomen. There is excessive thirst. Nausea sets in, followed by frequent retching and vomiting of mucus often tinged with blood and sometimes containing shreds of mucosa. There is diarrhea with frequent serous, mucous, and usually bloody stools. The pulse is small and frequent. The body of the victim is bathed in a cold perspiration. The victim exhibits great anxiety. The mucosa of the mouth and throat is white and shrivelled and in a short time there is severe swelling of the fauces. Often the swelling of the throat is so severe as to threaten asphyxia, and cases are known in which tracheotomy became necessary to save life. Breathing becomes difficult and dyspneic. A period of vertigo precedes insensibility, collapse, and death. Death may sometimes occur in convulsions. The fatal period is from twenty-four to thirty-six hours. The shortest time on record is a case recorded by Welch in which death took place in thirty minutes after swallowing the poison.

Subacute Poisoning.—The dividing line between acute and subacute cases is very vague, the former merging into the latter. Thus a case of acute poisoning in which life is prolonged may pass into the subacute stage. In addition to the general symptoms first given, there are seen the characteristic symptoms of poisoning by mercury. The vomited matter is thick, viscid, bilious in character, eventually becomes bloody and has a bad odor. The abdomen is usually, but not always, tense and painful to pressure. The face is alternately pale and flushed and expresses suffering, anxiety, and prostration. The sweat-covered body is without strength. The gums are inflamed, swollen, and painful. There is constriction of the throat, more or less severe cough, often with the expectoration of bloody matter. The breath is very fetid; the odor is peculiar, characteristic, and of great diagnostic value. The swelling of the gums is accompanied by sensitiveness of the teeth, which become loosened and may even be shed. Stomatitis is followed by salivation, becoming at times excessive. The saliva has the same characteristic fetid odor as the breath. Colic is followed by frequent, very painful (tenesmus) bloody stools, closely resembling those of dysentery. This diarrhea differs from that resulting from poisoning by arsenic, antimony, etc., in that the stools are, as a rule, more frequent, smaller, and composed chiefly of mucus tinged with bile and blood. There is generally complete or almost complete anuria; when the urine is not entirely suppressed it is albuminous. The failure of the kidneys to function is followed by uremia and the patient may die as a result of uremic poisoning. There may or may not be slight jaundice. In very protracted cases there is apt to be a weakening of the intelligence, a loss of muscular power, more or less marked edema accompanied by paralysis of the lower extremities; and an eruption on the skin, eczema impetiginosum. The temperature is normal or only very slightly raised, until the approach of death, when it is apt to fall with great rapidity. The pulse is small, weak, and thready. The skin of the patient feels cold and clammy. The respiration is generally dyspneic and asthmatic. A period of apparent convalescence may intervene after five or six days, the pulse increases in strength, the body warms up, the skin loses its clammy feeling, respiration becomes more regular and normal. This period of reaction is quickly followed by relapse, the patient falls into a state of great prostration, the pulse becomes small, weak, and imperceptible; there is syncope, loss of sensation, and coldness of the lower part of the body; there is more or less marked loss of speech, but the patient remains lucid to the last. Sometimes there is internal hemorrhage from the bowels, stomach, etc., accompanied by a great fall in temperature; Loewy records a case exhibiting a sudden fall of temperature to 33.4° C. (92.1° F.). The average fatal period is from eight to fifteen days.

The channel of introduction of the poison modifies slightly the symptoms observed. For example, pois-

oning from the excessive use of mercuric chloride in childbirth does not give rise to the acute stomatitis (stomatitis ulcerosa) seen in the introduction of the poison per os, though more or less inflammation and swelling are exhibited no matter what the channel of absorption. Toxic gastritis and enteritis also result from the introduction of mercury into the body no matter what the method of entrance.

Chronic Poisoning.—Chronic mercurialism is the result of constant exposure of the body to contact with mercury in some form, or to the frequent ingestion of mercurial remedies prolonged over a long period. In the arts, several industries give rise to chronic poisoning of workmen, as, for example, the mining of ores of mercury and the extraction of the metal from them; the manufacture of mirrors and of various preparations and salts of mercury; electrotyping, gilding; the manufacture of certain kinds of felt, of barometers, thermometers, and other instruments necessitating the use of mercury; the manufacture of fulminate of mercury and of percussion caps, etc., etc. Of these industries the most harmful are doubtless the mining and extraction of the metal. According to the statistics collected by Kobert, in the best ventilated and hygienically constructed and operated mines from one to two per cent. of the miners are afflicted with mercurialism; while in the extraction of the metal by heat fully eight per cent. of the workmen exhibit typical symptoms of chronic poisoning.

In chronic poisoning by mercury practically all the symptoms accompanying the subacute cases are seen but in a less aggravated form, and in addition there are several distinct and characteristic symptoms. First of importance among these characteristics must be placed tremor mercurialis. This affliction appears as an extraordinarily severe trembling of the patient, in which the upper parts of the body, especially the arms, are first affected. The movements of the lips and tongue are also altered so that speech may become confused and unintelligible. Tremor, as has been said, is most noticeable in the arms where it is almost convulsive in character and renders them vacillating. The seizures are brought on by any attempt at muscular effort and are often so severe as to necessitate the feeding of the victim. When the muscles are relaxed and the patient is quiet, only a twitching is observed, while during sleep no sign of tremor is seen. Children born of parents afflicted with tremor mercurialis have been known to exhibit termor, but in the majority of cases chronic poisoning leads to abortion. Accompanying tremor there is well-marked erethismus tending to aggravate the seizures of trembling. Resulting from anemia and gastric and enteric catarrh mercurial cachexia makes its appearance; this is seen in the anemic condition of the blood, the atrophy of the muscles, and the general wasting away of the body. Salivation is usually excessive. The specific gravity of the saliva secreted in the early stages of the disease is usually abnormally high, due to the presence of albumin; later, however, it falls again to the normal value or may be subnormal. Salivation is not a primary symptom but follows stomatitis and may disappear in very protracted illness. The gums are swollen, soft, hemorrhagic, and usually painful; often they show a dark line somewhat similar to that seen in chronic poisoning by lead. The breath is very fetid. Carious teeth decay with great rapidity, sound teeth are painful and loosened, and may even be shed. Necrosis of the jaw not infrequently results. The skin is more or less seriously affected, as shown by an eczematous appearance—eczema impetiginosum, or squamosum (eczema mercurialis)—or in more mild cases by urticaria. There may be falling out of the hair. The patient suffers from albuminuria, generally from obstinate and almost complete anuria, and is afflicted with mercurial cirrhosis of the kidneys. Often a distressing tuberuclosis-like cough is heard. Lastly, in very protracted cases many authorities believe that there results decalcifying osteitis, but upon this point there is some dissent; the weight of evidence, however, seems to show that calcium salts are withdrawn from the bones and deposited in the kidneys.

Evidence has been adduced at different times to show that the progress of the disease is more rapid in women than in men; however this may be, it is certain that some individuals are much more sensitive to mercurial action than others, and that persons having a tendency to tuberculosis rarely recover from chronic mercurial poisoning.

Children born of parents suffering from mercurialism are generally weak, frail, and show a decided tendency to tuberculosis.

Post mortem Appearances.—The symptoms exhibited in poisoning by mercury have been described in sufficient detail to indicate the chief pathological changes which will be seen in an autopsy. These changes are generally sufficiently characteristic to enable an expert to assert with a fair degree of confidence that death was due to mercurial poisoning.

The whole alimentary canal is more or less inflamed; the mucosa of the mouth and throat is red or even ulcerated, especially in the upper part, or in very acute cases it may be shrivelled and whitened; that of the stomach is ecchymosed, even ulcerated; in only one reported case has perforation been observed. The intestines are more strongly affected than is the stomach and may exhibit greenish-yellow ulcerations, especially in the lower part of the ileum; not infrequently the mucosa is edematous, swollen, and the submucosa infiltrated with serum. In such an event the intestines are anemic. These appearances follow the absorption of mercury by no matter what channel; and, save the whitening of the mucosa, are not confined to per os ingestion. Usually the large intestine exhibits macro- and microscopic appearances identical with those seen in dysentery. The liver and kidneys are anemic, enlarged, and show fatty degeneration unless death has been quite rapid. The liver may be icteric and pasty. Microscopic examination of this organ shows numerous fatty droplets and granulations in the cells in which the nuclei have been destroyed. The kidneys exhibit a somewhat analogous appearance which may sometimes be suggestive of Bright's disease. Sections of the kidneys (in subacute and chronic poisoning) placed under the microscope and treated with dilute sulphuric acid will be seen to give off a gas—carbon dioxide—due to the presence of deposits of carbonate of lime, and in a few seconds the tubuli will be seen to be clogged with characteristic acicular crystals of calcium sulphate formed by the action of the sulphuric acid. The bladder is contracted and usually empty. The muscles of the heart are hemorrhagic and show some fatty degeneration. This steatosis of liver, kidneys, and heart is analogous to that observed in cases of poisoning by arsenic and by phosphorus, but is not quite so severe as in these cases. The lungs are sometimes normal, more often full of blood, the result of bronchopneumonia. The muscles of the body are anemic with here and there ecchymosed spots; incisions made in the muscles lead to the exudation of a watery fluid. The blood in acute cases is usually dark, thick, and coagulates with difficulty. In chronic cases it is anemic. The mouth may appear grayish in color; this appearance occasionally extends down the esophagus. The walls of the intestines are not infrequently grayish or blackish from mercuric sulphide, the result of putrefactive changes. In a few instances it has been thought that this gray color has been the result of the deposition of very finely divided metallic mercury.

Antidotes.—The only satisfactory antidotes are albumin, such as white of egg, milk, flour and water, etc.; ferrous sulphate with reduced iron or ferrous sulphide; followed immediately by the stomach pump or emetics and purgatives, unless such action has al-

ready been induced. Prompt removal of the material from the alimentary canal is imperative, since the insoluble compounds of mercury produced by the action of the antidotes are all more or less rapidly acted upon by the fluids of the body. The administration of too great an amount of albumin is also probably objectionable, as there seems to be good reason for believing that the compound of mercuric chloride with an excess of albumin is more soluble than when the albumin is not in excess. It is better, therefore, to administer only just the amount which it is judged will render the poison insoluble; then remove the precipitate and administer a fresh dose of the antidote. The white of one egg will render about 260 milligrams (gr. iv.) of mercuric chloride inactive. Stomatitis is best treated by frequent gargles or washes of potassium chlorate. In the treatment of chronic poisoning zinc phosphide has given excellent results. Tremor mercurialis can be more or less successfully treated with electricity. There is at present much diversity of opinion as to the value of iodides and of sulphur compounds such as flowers or liver of sulphur, sulphureted hydrogen waters, etc. There are reasons for believing that although good results have, in many cases followed the use of these disputed remedies, their efficacy has been somewhat overestimated.

All rooms and buildings, etc., in which either metallic mercury or its salts are employed should be exceptionally well ventilated and every possible precaution should be exercised to avoid spilling material on the floors, work-benches, etc. The most scrupulous cleanliness of all workmen should be insisted upon. The floors of the rooms should be free from all fissures and cracks and should slope gradually from all sides toward the center in order to facilitate cleaning. Meyer has suggested the sprinkling of the floors with dilute ammonia each day after the day's work is done.

Elimination.—Mercury seems to be eliminated from the body through all the secretions, but chiefly by the glands of the stomach and intestines in the feces, by the kidneys in the urine, by the salivary glands in the saliva, and by the liver in the bile. For the clinical detection of mercury either the urine or the saliva may be employed. In acute cases the greater part of the poison will be ejected in the vomited matter.

Mercury is known to persist in the body for long periods after all ingestion has ceased. The usual period of elimination in acute poisoning by corrosive sublimate is probably about thirty days, but the metal may persist for months. In subacute cases the period of elimination is thought to be about six months; while following chronic poisoning, mercury is slowly eliminated from the body during periods of almost incredible length. Ogier cites a case communicated by Vadja and Pachkis in which mercury could be detected in the urine thirteen years after the cessation of mercurial treatment!

According to Hoffman, when vapor of metallic mercury is inhaled there is observed the elimination of free metallic mercury in the urine; several other experimenters have observed the same phenomenon.

Mercury seems to possess a marked cumulative action and is localized chiefly in the liver and kidneys, from which organs it disappears only very slowly. It can be detected in the liver, in most cases, after it has disappeared from other organs of the body.

Mechanism of the Action of Mercury.—Science has not yet reached a stage where we can formulate a satisfactory theory for the cause of the action of mercury. Lack of space forbids a discussion of the various hypotheses which have been advanced; suffice it to say that none of them is wholly satisfactory.

Owing to the great affinity of mercury for the nitrogen compounds of the tissues, albuminates of mercury or analogous combinations are formed, causing the death of the cells. This layer of destroyed cells is not impermeable but allows deeper and deeper progressive action, due in part to the penetration of a fresh supply of the poison or to the resolution of the mercury in the albuminate first formed. It is probable that the mercury circulates in the blood in the form of what has been called mercuric chloride-albuminate or sodium chloride-mercuric albuminate, soluble compounds of unknown composition. The result of the circulation of these poisonous compounds is the death of cells, etc., as shown by the progress of the disease in stomatitis, gastritis, enteritis, salivation, and, even in the early stages, in ulceration of the glottis. That these symptoms are not the result of contact but are of secondary action through the blood is proved by the fact that they appear when mercury is applied externally (ointment) or injected subcutaneously and when only the faintest trace of mercury has reached the intestines. In circulating through the liver the mercury produces an abnormal secretion of bile, accompanied, according to some investigators, by the destruction of countless blood corpuscles, the latter being deposited in this organ, and giving rise to its fatty infiltration, and to anemia and cachexia. An analogous action takes place in the kidneys where the changes produced in the tubuli give rise to albuminuria and uremia. In a short time after circulating through the body mercury causes more or less marked paralysis of the muscles and of the heart; this Rabuteau believes to be due to the destruction of the contractility of the muscles without any action on the motor nerves. According to this view the cardiac paralysis observed soon after the administration of a very large dose is due to the loss of contractile power of the cardiac muscles and is not the direct result of neural paralysis. The experiments of von Mering have shown that mercury exerts a decided and very deleterious action on the vaso-motor system and on the heart. In prolonged illness there can be no doubt that mercury exerts a specific action upon the central nervous system; since we observe erethismus mercurialis and a weakening of the intelligence, perhaps the tremor can be ascribed in part to this action. One of the most remarkable of the effects of mercury is that of the dissolving of calcium salts in the bones, to which reference has already been made; the lime thus extracted is eventually deposited, in part at least, in the kidneys, apparently as the carbonate, clogging the canals (see von Weichselbaum, *Centralbl. f. Path.*, 1891, 1). How and why this action is brought about is unknown.

Kaufmann believes death to be the result of primary intravital multiple capillary embolism in the kidneys and that this is shown in epithelial necrosis, calcification, and capillary thrombosis. Jolles, on the other hand, believes death to be the result of capillary embolism, not in the kidneys but in the intestines.

Clinical Tests for Mercury.—The urine and the saliva are the most satisfactory materials upon which to work. In case the urine is employed it is best to concentrate it to about half its volume. Acidify the solution to be tested with pure hydrochloric acid. Introduce two or three tiny strips of pure bright copper foil about one millimeter wide by three or four millimeters long. Heat almost to boiling for from ten to fifteen minutes. Pour off the liquid from the foil and wash the latter first with water, then with alcohol, and dry by pressing gently between sheets of filter paper. If mercury is present the copper foil will be coated with a gray or silvery film. A gray film gently rubbed with the end of a finger becomes bright and silvery. The mere deposition of a film upon the copper should not be taken as conclusive evidence of the presence of mercury. In order to confirm the presence of this element the perfectly dry foil can be introduced into a small glass tube closed at one end. The tube should then be heated at a point from about three to five centimeters above the roll of copper foil and drawn out to a bore of say two millimeters, care being taken to avoid heating the bit of coated copper. When the tube thus

prepared is perfectly cold, the end containing the foil is heated red hot in a Bunsen or alcohol lamp. The mercury amalgamated with the copper is thus vaporized and condenses on the walls of the tube; by progressively heating the tube above the foil all the mercury is driven into the constricted part of the tube and an examination with a microscope or pocket magnifier will disclose many tiny silvery globules of metallic mercury. In case the globules are very minute, rubbing the deposit with a fine iron wire or with a drawn-out glass rod will cause them to unite into globules large enough to be readily detected. Although this reaction is a very delicate one, it can be rendered even more delicate by converting the sublimate of mercury into red mercuric iodide. This is accomplished by proceeding as follows: The closed end of the tube is cut off, a small fragment of iodine introduced, and the end of the tube closed with a tiny cork. Thus prepared the tube is laid in a warm place for half an hour or more. The slow vaporization of the iodine causes the formation of brilliant red mercuric iodide which is generally easily visible to the naked eye if the tube be held over white paper. Too high a heat will cause the sublimation of much iodine, thus masking the red color of the iodide. In such an event a gentle current of air drawn or blown through the warm tube will remove the iodine. By this iodine method 0.1 milligram of mercuric chloride can be detected with ease, and with great care the delicacy can be pushed to beyond 0.01 milligram.

Instead of copper foil a little spiral of thin pure gold foil (dental foil) can be wound around a tiny rod of metallic tin or zinc. The electrolytic couple thus obtained is dropped into the acidulated liquid to be tested. No heating is necessary. After several hours the couple is removed, washed, dried, and heated in the manner suggested above. Most of the mercury amalgamates with the gold, but a part is always deposited upon the tin or zinc; hence after carefully unrolling the gold each part of the couple should be tested.

Another method consists in winding a spiral of platinum foil around a common steel sewing needle, introducing this couple into the liquid and proceeding as described above.

A very convenient arrangement when employing a couple is to drop it into a separatory funnel of suitable size, pour in the acidulated liquid, and open the stopcock so that tiny drops fall very slowly. To make doubly sure, the liquid can be poured back and again allowed to come in contact with the couple.

Solid organic matter can be brought into solution by treating with hydrochloric acid and potassium chlorate on the water-bath. The strongly acid solution thus obtained should be partly neutralized with sodium bicarbonate and tested for mercury by any of the above-mentioned methods.

EMILE MONNIN CHAMOT.

Hydrarthrosis Intermittens.—*Synonyms:* Intermittent Joint Hydrops, Intermittent Synovitis This rare and somewhat mysterious lesion was described first by Perrin[1] in France. It consists essentially in a periodic effusion into one or more joints, most frequently into the knee. The fluid remains for a few days and then disappears, but Linberger[2] by careful measurements determined that in one of his cases the disappearance was only partial, and that the joint remained swollen in the interval. In other words, if this author's findings be confirmed, the very name that we attach to the lesion is incorrect, and requires to be changed to "remittent" hydrops, or remittent synovitis. The duration of the swelling and the length of the intervals vary. Usually the attacks come on rather rapidly, the swelling increases for several days, and then gradually subsides. The interval as a rule varies in the different cases between one and two days, and the duration of the swelling from two to eight days. The intervals may be shorter or much longer.

Sometimes the patient can foretell the exact day and hour of his attacks, with such regularity do they occur. If several joints be affected, they may swell coincidentally, or one after another. Occasionally the disease leaves one joint and appears in another. Pain, though sometimes present, is not wont to be a prominent symptom. Fever, headache, dizziness, pain in the extremities, and other constitutional symptoms have been observed in some cases. Cases that have been regular in their recurrence may become irregular and *vice versa;* again the length of the interval may change. The disease occurs with about equal frequency in men and in women. In women the attacks have sometimes subsided during pregnancy, and a certain relation to the menses occasionally has been noted.

CAUSE.—This is unknown. The disease has been regarded as an angioneurosis (Barker,[3] Seeligmüller)[4] and as the result of infection. In certain cases a history of trauma has been obtained. Naturally "rheumatism," that vague and all-embracing process, has often been held responsible. Coincident disease of the thyroid gland, or exophthalmic goiter, has been observed. On account of its periodicity, a malarial basis has been sought for intermittent hydrops, but none has been found. In fact malaria is one of the few infectious diseases in whose course or sequence joint inflammations are never seen. Payr[5] maintains that an intermittent hydrops may be a symptom of joint lues.

PATHOLOGICAL ANATOMY.—The synovia is often the seat of a villous hypertrophy. The fluid is usually serous and yellow in color, and it may contain flakes of fibrin. The spleen may be enlarged. Linberger maintains that intermittent hydrops is essentially the result of a joint inflammation, not a passive effusion, and that it is a symptom of various diseases and not a disease itself. Klemm,[6] Garré, and others noted the occurrence of an intermittent hydrops as a symptom of an enclosed chronic suppurative osteomyelitis in the ends of the long bones.

TREATMENT.—Drugs, almost without number, have been tried, usually in vain. The best results have been obtained with quinine and arsenic. Various baths have been recommended, with all sorts of ingredients. The usual gamut of external applications, and of heat and cold has been run. Some surgeons have aspirated the joint and have washed it out with water, iodine, carbolic acid, etc., and in a number of instances with apparently good result, though the procedure does not seem rational.

I have never seen a typical case of intermittent hydrops, but in a case of recurring synovitis of the knees, I observed a disappearance of the symptoms following a washing out of some cheesy crypts in the tonsil.

LEONARD W. ELY.

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Hydrastis.—GOLDEN SEAL. "The dried rhizome and roots of *Hydrastis canadensis* Linné (Fam. *Ranunculaceæ*), yielding, when assayed by the process given below, not less than 2.5 per cent. of hydrastine." (U. S. P.)

The *Hydrastis canadensis* is a small herbaceous perennial plant with an erect, simple, pubescent stem, from six inches to one foot in height. There are usually but two leaves, one at the top of the stem, the other attached a short distance below. The leaves are pubescent, roundish, generally five-lobed. The flower is solitary and rises from the base of the upper leaf. It is whitish or purplish and consists of a colored calyx which falls very shortly after the flower expands. The fruit is a globose, compound berry, somewhat resembling a raspberry. The rhizome is of oblique growth, 2.5 to near 5 cm. (1 to nearly 2 in.) long, and 0.5 to 1 cm. ($\frac{1}{5}$ to $\frac{2}{5}$ in.) thick, cylindraceous, usually with a few short branches, longitudinally wrinkled, but plump, somewhat annulate, externally brownish-gray, often with a yellow tinge or yellowish patches; fracture short and sharp, waxy, golden-yellow or bright reddish-yellow, with a thickish bark, about ten short and narrow wood wedges and broad medullary rays; roots, if present, rather coarse, brittle, with a thick bark and somewhat quadrangular wood; odor slight, characteristic; taste very bitter, but not disagreeable, producing a somewhat astringent effect.

The plant is indigenous to North America and grows abundantly in the north and west of the United States and Canada. Only one other species of hydrastis is known, *H. jezœnsis* Sieb., which is found in Japan.

The enormous demand for hydrastis has caused its price to advance within twenty-five years from less than ten cents to five dollars a pound, and seriously threatens the plant with extinction in the wild state. Great efforts have been made, especially by the Bureau of Plant Industry, of the U. S. Dept. of Agriculture, to develop its cultivation. This has been found difficult, owing partly to the low germinating power of its seeds, and partly to the slowness of propagation by root cuttings. Nevertheless, the cultivation of hydrastis can be conducted with great profit, under the prevailing high prices, by those who are properly qualified for the work. Those who are not cannot expect to succeed.

The therapeutic properties of hydrastis depend upon the active principle *hydrastine*, which is separated in white crystals, without odor or taste, and insoluble in water. With acids it forms salts which are freely soluble in water. Much trouble has arisen from the confusing of this name with *hydrastin*, an "eclectic" extract, which is made up of the various alkaloids and resin, and is many times weaker. It is a yellowish powder. *Hydrastinine* is an artificial alkaloid formed by the oxidation of hydrastine, which breaks up into hydrastinine and opianic acid. The hydrochlorid is official in the United States Pharmacopœia, and occurs as light yellow, amorphous granules, or as a pale yellow, crystalline powder, odorless, but with a bitter, saline taste. It deliquesces upon exposure and is very soluble. *Berberine* is also present and the tonic properties of the plant are, in a manner, due to its action.

Hydrastis exercises, both locally and after absorption, an action upon the system which is beneficial in all states of congestion and hyperemia. The results of physiological experiments with hydrastine show that it increases the activity of the nerve centers. In this respect it exhibits resemblances to both strychnine and picrotoxin. Both the sensory and motor functions are stimulated and reflex action becomes very marked. The tone of all muscular tissues is particularly raised, the striped, unstriped, and cardiac cells being influenced, as a result of which effect there is produced an acceleration of heart action and of the circulation throughout all tissues. A like effect is manifested upon the uterine tissue, and this effect, if the uterus is in the pregnant state, may prove sufficient to cause abortion. There is also produced an increased activity in all the secreting organs, the flow of saliva, bile and other intestinal secretions being greatly augmented. The urine is also increased, and the alkaloid may be detected in the urine within twenty-five minutes of its hypodermic injection.

In excessive doses the action of the drug somewhat resembles that of strychnine. There are excessive motor activity with cardiac distress, and convulsions which may prove fatal. In the latter event death results from extreme depression followed by respiratory failure. In a case reported[1] two doses of twenty drops of the liquid extract produced most alarming cardiac distress in a case of bronchitis with copious expectoration. The lethal dose is given by Cerna as 0.5 gram for each kilogram of body weight.[2] Phillips and Pembrey[3] during experimental work upon animals found that death followed 15.4 grains when given to a full-grown cat.

The action exerted upon the blood-vessels has led to its employment as an hemostatic. Attention was directed to its use for this purpose in Germany in 1883 by Dr. Schatz, at a meeting of the Association of Physicians and Naturalists. He reported decidedly in its favor for the treatment of chronic hyperemia and chronic inflammation of the internal genital organs attended by losses of blood. Since that time it has been extensively employed with very general satisfaction. In menorrhagia and metrorrhagia without organic disease, as in the various forms of metritis and endometritis, it is said to check the flow more rapidly than any other remedy. In the hemorrhages occurring at the climacteric, and the excessive menstruation of young girls in which the tissues are relaxed and congested, it has proved itself particularly useful. It also relieves all conditions of congestion of the pelvic organs, ovarian pains, dysmenorrhea, and other distressing symptoms arising from this cause. Its effect when the hemorrhage is due to myomata appears to be uncertain, some observers claiming for it decided curative properties, while others have failed to derive any benefit from its employment. It should be administered with care during pregnancy on account of its tendency to provoke abortion, although many claim to have used it without any ill effect. One of the earliest applications of hydrastis was as a cardiac tonic, and its effect upon the heart makes its action very similar to that of digitalis. It is not equal to the older drug, but has been found very serviceable when a change from digitalis is necessary.

As a local remedy hydrastis exerts a marked action upon mucous membranes whenever altered by local congestion. It is astringent and tonic, lessening the congestion, and promoting a freer and better circulation in the part. It is employed in all catarrhal conditions of the vagina, urethra, rectum, nose and pharynx, in their subacute or chronic stages. It also exercises the same local effect upon the mucous membrane of the stomach and bowels when administered internally, and has proved of benefit in all catarrhal conditions of these organs, its local action being assisted by the increased secretions of the liver and other intestinal secretions. In hemorrhoids it is thought to act with much advantage.

The fluid extract is the preparation looked upon with most favor for local use. When diluted with water it makes an undesirable-looking mixture, but it offers the advantage of depositing the insoluble resinous material directly upon the mucous surface, which is considered most necessary if its full effect is to be secured. The strength of the solution should be from ten minims to two drams to the ounce. For rectal and vaginal use it may be applied in the form of suppositories. For internal use the dose is from one-half to one fluidram.

Hydrastine has been used as a wash, in the strength of two to five grains to the ounce, as a substitute for the extract, but has not proved as serviceable. For internal use it is to be preferred, as it possesses the hemostatic and tonic action of the drug, and is of a more definite strength. The dose is from one-eighth

to one-half grain, and may be given in all conditions in which hydrastis is indicated.

The eclectic remedy, hydrastin, has been employed for many years as a stomachic, tonic, and antiperiodic, but is never used for any hemostatic action.

Hydrastinine hydrochlorid is probably the most desirable preparation for internal administration. It acts rapidly, and reports indicate that its action is more trustworthy than is that of hydrastine or the fluid extract. The dose is from one-half of a grain to one grain and a half, every three to six hours. It may also be given hypodermically in a ten per cent. solution in distilled water.

The high price of hydrastis and its products makes it possible to market profitably artificial or synthetic hydrastinine hydrochloride, manufactured from heliotropin, and apparently identical therapeutically with the natural compound. HENRY H. RUSBY.

Hydrazine, $NH_2.NH_2$, is a strongly basic body exerting a peculiar influence upon the organism in that animals that have received subcutaneous injections of it show a greatly reduced blood sugar content. The liver shows a typical pale appearance resembling that of the so-called fatty degeneration. Hydrazine appears to cause an entire disappearance of sugar from the body without inducing glycosuria.

F. P. U.

Hydriodic Acid.—Hydriodic acid (HI), is a gaseous body, freely soluble in water. The aqueous solution, however, is very unstable, constantly tending to disengage free iodine. Accordingly the United States Pharmacopœia makes official *Acidum Hydriodicum Dilutum*, Diluted Hydriodic Acid, which is a solution of hydriodic acid containing not less than 10 per cent. by weight of the absolute acid, and about 90 per cent. of water. It is "a clear, colorless liquid, odorless, and having an acid taste; specific gravity about 1.106 at 25° C. (77° F.); miscible in all proportions with water or alcohol" (U. S. P.). Diluted hydriodic acid is used as a substitute for iodine and the iodides, and is given in doses of about 10 to 30 minims (0.6 to 2.00 c.c.).

Another official preparation is the *Syrupus Acidi Hydriodici*, Syrup of Hydriodic Acid, wherein the acid is preserved from change by the presence of sugar. The syrup is clear and colorless, or slightly straw-colored, and contains one per cent., by weight, of absolute hydriodic acid. It has a sweet, acidulous taste. Syrup of hydriodic acid has similar general properties to the other diluted sour mineral acids (see *Sulphuric Acid*), but its special employment in medicine is, because of the iodine of its composition, as a substitute for the alkaline iodides. It seems beyond question to possess the general medicinal properties of the iodides, and may be given in doses of from one-half to one teaspoonful, well diluted, several times daily. EDWARD CURTIS.
R. J. E. SCOTT.

Hydroa Vacciniforme.—This affection was first described by Bazin in 1855, but for a long time thereafter was generally lost sight of. In 1888 Hutchinson described what is undoubtedly the same affection, under the title "summer eruption." A year later, Handford published in the *Illustrated Medical News* a series of cases which he proved were identical in nature with both Hutchinson's summer eruption and Bazin's hydroa vacciniforme. Since then numerous cases have been reported by English, German, and American writers, and it has been shown that the disease, although rare, is not so uncommon as had been supposed. In France, strangely enough, the affection escaped recognition after Bazin's original description, but of late it has been again described by Brocq and others.

The affection usually begins in the first years of life and has been found to be much more frequent in the male sex. The parts of the body chiefly affected are those that are unprotected and exposed to the rays of the sun, although in a number of instances it has been seen on other parts as well. The bridge of the nose, the cheeks, and the ears are most prominently affected, and next in order come the backs of the hands. Other parts of the body, if exposed to the sun, will be equally affected, as in one instance in which it appeared on the legs of a boy who went about with trousers rolled up. In a case seen by the writer, however, no lesions ever appeared on the lower extremities, although the child went barefoot during the summer. The affection comes in attacks, usually in the summer season and on exposure to the sun, although this cannot be laid down as an absolute rule, as in some instances there have been quite numerous attacks in winter. There is no itching, as a rule, yet in one of the writers's cases it was marked.

At the outset of an attack there may be slight constitutional disturbance. The first appearances are either vesicles or small red papules which rapidly become transformed into vesicles and bullæ of varying size and which often become confluent. A marked feature, which has given the affection a part of its title, is the umbilication that occurs in many of the lesions, so that a vaccination vesicle is closely simulated. The depressed center is usually surrounded by a ring of fluid, while there is a red areola at the periphery. The center is dark blue or black, due to the hemorrhagic and necrotic condition of the corium, which is seen through the overlying vesicle. The lesions frequently become purulent. As a rule the attacks last several weeks, but may be much prolonged by exacerbations. The center of the lesions dries into a thick, black crust, extremely adherent, and which finally on dropping off leaves a distinct pit. In many of the cases the scarring is quite severe, and reminds one forcibly of that left by a severe variola. The tip of the nose and the edges of the outer ear are in some cases much deformed. The attacks become milder and less frequent toward puberty and usually cease by the time adult life is reached.

Histologically, according to the writer's examination, which has since been essentially confirmed by Mibelli, the small primary vesicle is shown to have its seat in the middle layers of the rete Malpighii. The upper portion of the rete is somewhat reticulated, but the fluid divides the middle from the upper layers so that a large chamber without network is produced. In the fully developed lesion, with dark umbilicated center, there is found a necrosis of the central portion of the nodule. The outer horny layer is unbroken and stains well, while the lower horny layers have become necrotic. The middle and lower layers of the rete are converted into a reticular tissue, forming a network filled with granular detritus and leucocytes, and this network has become necrotic. This necrosis extends downward through the entire corium, ceasing just above the subcutaneous tissue. The corium has a distinctly abnormal appearance, the connective-tissue cells having lost in great part their capacity for receiving stains. The connective-tissue fibers are broken up and forced apart and contain in their interstices deeply staining granules and detritus. In the papillary layer are large necrotic blood-vessels filled with blood cells, together with some free hemorrhage into the tissue. The necrosis ceases abruptly at the sides and base of the lesion. There is some increase in thickness of the epidermis adjacent to the necrotic portion. Malinowski in a recent article (1906), thinks that a necrosis of the epidermis, quickly followed by a similar process in the corium, is the primary phenomenon, and that the inflammation is secondary.

From these appearances it is seen that the disease begins with an inflammation in the rete and upper portion of the corium in a circumscribed area, and quickly produces a vesicle in the rete. Immediately after this a necrosis sets in, which affects the epidermis and almost the entire corium. The dilated and necrotic blood-vessels can be seen through the transparent vesicular covering, and give rise to the dark red hemorrhagic center seen clinically.

The cause of this peculiar dermatosis is unknown. The most plausible theory is that of a vasomotor neurosis, which in certain individuals causes, when they are exposed to the sun's rays, a circumscribed inflammation followed by necrosis. Ehrmann's experiments with Finsen and other forms of light, would indicate that it is an enormously increased individual sensitiveness to the chemical rays that is at fault, others think that it is the heat rays.

White has described several instances which probably belong in this group, which presented some unusual features, so that it seems probable that the classical description ought to be enlarged somewhat. The exceptional features in these cases were the cessation of all activity during the warm months for ten consecutive years in one case, the continuance of the attacks throughout the whole year in another, together with failure to be influenced by exposure to sun or weather, and an extensive distribution of lesions covering a large portion of the body, instead of a limitation to the portions exposed to the influence of the sun. The lesions in these cases were also very large, and the scars left very prominent and disfiguring.

A number of cases of this affection in which the urine contained hematoporphyrin have been reported. Linser found that hematoporphyrin appeared in the urine after exposure to *x*-rays, and also after exposure to the ultra-violet rays of the Finsen light, in a case of hydroa vacciniforme in which the urine was otherwise free from this substance. Ehrmann thinks that the reaction of the skin may depend upon the presence of hematoporphyrin in the tissue.

It is very difficult to classify hydroa vacciniforme, although there are several affections which seem to be somewhat related to it. Boeck's acne necrotica has numerous points in common with the affection we are considering, such as the circumscribed necrosis, the umbilication, and the enlargement of the blood-vessels with hemorrhage. The histological appearances in a case reported by Touton were also similar. It is still a matter of discussion whether acne necrotica and acne varioliformis are the same disease, so that the relationship of hydroa vacciniforme and acne varioliformis is also indicated. We have also a peculiar congenital bullous dermatitis, first described by Hallopeau and characterized often by the persistence of scars and epidermic cysts, which offers some analogy to hydroa vacciniforme, chiefly in the repeated occurrence of bullæ followed by scars and the fact that a favorite but by no means exclusive seat is the head and the backs of the hands. It may also sometimes be excited by the action of the sun.

It is most probable that the chemical rays of the sun play some part in this affection as they have been supposed to do in eczema solare, etc. Hutchinson has described cases of recurrent papular, pruriginous, and eczematous eruptions occurring chiefly on the exposed parts of the body during the summer months. Hence we have evidence that the sun's rays may cause not only superficial inflammatory cutaneous changes, but deep sharply bounded necroses.

Treatment.—The importance of prophylaxis is apparent—to guard the patient from the sun's rays, or from wind and storm. Protecting and soothing applications are indicated when the eruption is active. Veils of red and turmeric, which are supposed to neutralize the chemical rays, have been recommended by Unna in eczema solare and may be employed in this affection. Crocker recommends the trial of arsenic, quinine, and belladonna internally.

John T. Bowen.

Hydrobromic Acid.—Hydrobromic acid, HBr, is a gaseous body which, in ten-per-cent. aqueous solution, constitutes the preparation official in the United States Pharmacopœia under the title *Acidum Hydrobromicum Dilutum*, Diluted Hydrobromic Acid. This preparation is "a colorless, fuming liquid, of a pungent odor, and an intensely acid taste; the fumes and odor disappear on diluting the acid with two volumes of water. Specific gravity about 1.158 at 25° C. (77° F). Miscible, in all proportions, with water or alcohol" (U. S. P.).

Diluted hydrobromic acid ranks among the sour mineral acids, and is perfectly competent to fulfil the purposes described under diluted sulphuric acid. Its special application in medicine, however, is not the utilization of its sour qualities, but its employment on the one hand as a *bromide*, in substitution for the alkaline bromide salts, and on the other as a vehicle for quinine, claimed to lessen the disagreeable by-effects of the alkaloid, while not interfering with the medicinal activities of the same. As a bromide-bearing medicine, the diluted hydrobromic acid has proved itself efficient if given in adequate dose, and to have less tendency than the bromides to produce acne and the other symptoms of bromism. In using the acid for its bromine influence, its comparatively feeble strength must be borne in mind, and the dose made to correspond, in proportion of bromine represented, to the average dose of the alkaline bromides. This correspondence is no less than about seven to one, so that it takes nearly seven parts of the pharmacopœial acid to equal, in bromine strength, one part of potassium bromide. To get, therefore, the bromine effect of the moderate daily allowance of 4 gm. (℥ i.) of potassium bromide, from six to seven teaspoonfuls of the acid would require to be given. Such doses, however, are liable to irritate the stomach, and accordingly the medicine is used most commonly in association with some bromide salt, in cases in which a full bromine effect is wanted. The acid should be diluted, for administration, ten- or twelvefold, and the mouth well rinsed after each dose.

Edward Curtis.
R. J. E. Scott.

Hydrocele.—*Definition.*—Hydrocele is a collection of serous fluid in the tunica vaginalis testis, or in some of its remnants in the cord.

Varieties.—Various classifications of hydrocele have been given, but the one of Jacobson is perhaps the best, and as presented by Guiteras is as follows:

Hydrocele: *Acute.*—A temporary collection of fluid in the tunica vaginalis due to traumatism or inflammation of the testis or epididymis.

Chronic.—A permanent collection of fluid in the tunica vaginalis or connected with the cord or epididymis.

I. Chronic Hydrocele of the Testis.

A. Hydrocele of tunica vaginalis; when the fluid is in the cavity or a sac connected with it. (1) Ordinary type. The fluid distends the tunica vaginalis of the testis. (2) Congenital. When the vaginal process is not closed and there is a communication between the cavity of the tunica vaginalis and that of the peritoneum. (3) Infantile. When the tunica vaginalis and the vaginal process are distended with fluid up beyond the usual point of obliteration, as far as the external ring. (4) Inguinal. Hydrocele in case of a retained testis.

B. Encysted hydrocele; when the fluid is in a sac distinct from the tunica vaginalis. (1) Encysted

hydrocele of epididymis. The fluid is encysted in or near the epididymis. (2) Encysted hydrocele of testis. When the fluid is encysted between the tunica albuginea and the visceral surface of the tunica vaginalis.

II. Chronic Hydrocele of the Cord.

A. Diffuse. The fluid forms a serous collection of the nature of edema in the cellular tissue of the cord.

B. Encysted. (1) The fluid is in a distinct sac originating in some unobliterated part of the vaginal process. (2) The fluid is in a cyst formed independently of the vaginal process.

III. Complications.

A. With other Coexisting Hydroceles, *e.g.* (1) Hydrocele of the tunica vaginalis with encysted Hydrocele of the testis. (2) Hydrocele of the tunica vaginalis with encysted hydrocele of the cord. (3) Hydrocele of the tunica vaginalis with diffused hydrocele of the cord.

B. With Hernia: (1) Hydrocele of the tunica vaginalis with inguinal hernia. (2) Hydrocele of the cord with inguinal hernia.

IV. Hydrocele of the Sac of a Hernia.

Acute Hydrocele.—Acute hydrocele is practically always a symptom of some acute process in the testicle or epididymis, or it may follow the injection of a chronic hydrocele. The underlying pathological condition, of which the acute hydrocele is only a symptom, is the important consideration in both the diagnosis and treatment. Acute hydrocele is seen most frequently accompanying acute gonorrheal epididymitis, and it may be seen with trauma to the testicle.

The tunica is red and injected, at times may be covered with a fibrinous exudate and the fluid is usually slightly turbid.

The symptoms of the underlying pathological condition, of which the acute hydrocele is a part, predominate. There is redness and swelling of the scrotum, which at times may even be edematous. Fluctuation can be elicited and unless the fluid is very turbid, the swelling transmits light. There may be more or less tenderness, depending on the severity of the primary condition causing the hydrocele. Constitutional symptoms, such as fever, gastric disturbances, etc., depend on the etiological factor. The acute hydrocele seen with acute epididymitis subsides in from three or four days to two weeks. Failure of the hydrocele to absorb results in the production of a chronic hydrocele, which may develop later even in cases in which the fluid does absorb, but in which the tunica has undergone changes.

This condition is best treated by rest in bed with elevation of the parts, and the application either of heat or cold. Usually the patients do better with hot, moist applications. Where the absorption of the fluid seems to be slow, one may resort to tapping. Counter-irritation may be made by scratching the parietal tunica with the end of the trocar. Tapping is especially advantageous where there is much tension and pain.

Chronic Hydrocele.—Chronic hydrocele is described as idiopathic and symptomatic, the former term being applied to the cases without any apparent etiological factor. This has been disputed by many authors who believe that each hydrocele has a definite factor in its production and is therefore a symptomatic hydrocele.

Keyes does not accept this theory "since it does not explain why idiopathic hydrocele is so common in the tropics, or why idiopathic hydrocele does not often follow acute epididymitis, a disease which leaves far greater changes in the epididymis than those alleged to be causes of idiopathic hydrocele."

Etiology. *Climate.*—By far the largest number of hydroceles occur in the tropics, where it is said that about one man in twelve has a hydrocele. It occurs less frequently in temperate climates.

Age.—Hydrocele may occur at any age of life, being seen in infants and children as well as in old men. According to the statistics of Bramann, it occurs most frequently between the ages of twenty and thirty, then in the ages below twenty, and diminishes in frequency above fifty. The figures of Krönlein are at variance with those of other authors. In his series thirty nine per cent. occurred in children under one year of age, and 48.8 per cent. during the first five years of life. In a series of 500 cases, Bramann found seventy per cent. occurring in adults.

Trauma.—Trauma as a factor in the production of hydrocele has been variously estimated anywhere from thirty to seventy per cent. In many cases it is difficult, however, to obtain a history of trauma. Traumatism as a factor has been mentioned in the congenital cases, especially in breech cases and where version was performed.

Gonorrheal Infection.—This without doubt probably plays a larger rôle in the production of hydrocele than is usually ascribed to it, and one can often elicit a history of previous gonorrheal epididymitis where a history of trauma cannot be obtained. According to Barthels this is an etiological factor in nineteen per cent. of cases.

Phimosis.—Sometimes phimosis and hydrocele occur together in infants. From the fact that the hydrocele disappears soon after the circumcision, it has been argued that the phimosis is a causative factor.

Varicocele Operations.—This operation is sometimes followed sooner or later by the development of a hydrocele on the same side of the varicocele operation.

Pathology.—The fluid is usually clear, of a golden yellow color, neutral in reaction and of a serous or fibroserous character. The specific gravity varies from 1020 to 1026. The amount of fluid present in the average hydrocele varies from a few ounces to a half pint. At times a hydrocele reaches an enormous size, containing in one case twenty-six liters of fluid (Bonisson).

Cholesterin crystals may be found in old, long standing cases. Hydrocele fluid is rich in albumin; it may be milky, due to the presence of spermatozoa. In the cases in which hemorrhage preceded the onset of the hydrocele, small fibrinous bodies may be found.

The tunica is more or less thickened. In the cases previously treated with injections, the tunica is very much thickened, hard and irregular on its surface. Small white patches, as well as areas of calcification, are present in the old cases. If the injection treatment has been accompanied by severe local reaction, or if it has been repeated several times, adhesions are found between the visceral and parietal layers. These adhesions may be very extensive so that only a small space remains between them. Rarely suppuration occurs, resulting in the production of empyema of the tunica.

The testicle is found on the posterior aspect of the hydrocele. Its position, whether high or low, depends on the amount of fluid present. In long standing cases the testicle and epididymis are often very much atrophied.

Symptoms.—The onset is insidious and the rate of growth is slow. Sometimes, after a hydrocele has been small and present for a long time, it begins to enlarge perceptably. Early in its course of development pain is absent, the patient's attention being first called to its presence by the enlargement and fullness of the scrotum. Later, because of its weight, the patient complains of a heavy dragging feeling in the scrotum and cord, which is often referred to the back. When the swelling becomes larger, it interferes with walking, and sometimes these patients tire very easily. Larger hydroceles are sometimes accompanied with an eczema of the scrotum and in the inguinal folds. Because of encroachment of the hydrocele on the penis, the acts of urination and copulation are interfered with. The

impotence is only temporary, being relieved by the removal of the hydrocele. Where there has been much encroachment on the penis, it is impossible for the patients to project the stream over the scrotum.

The skin covering the hydrocele is tense but remains freely movable. Hydroceles are pear-shaped and have a fluctuating consistency. On close examination a well-defined upper limit can be made out; that is, there is no connection between the upper end of the hydrocele and the inguinal canal.

One of the characteristic symptoms of hydrocele is its ability to transmit light, and while it is one of the oldest symptoms on which the older surgeons relied for diagnosis, it is the one symptom mostly used and relied on to-day. This is quite spectacular when presenting these cases to students, and when positive is almost practically pathognomonic, the only other symptom more certain being aspiration. Failure to elicit this symptom in a suspected case does not exclude hydrocele, as many hydroceles with excessively thickened tunicas may not transmit light. It is well to bear in mind that certain solid tumors of the testicle may transmit light. This method also determines the position of the testicle before aspiration or tapping.

This test is best carried out in a dark room by putting an electric light on one side of the scrotum, and either standing off at a distance or by looking through the scrotum with a tube of heavy paper. A straight endoscopic tube answers very well.

Diagnosis.—This is made by the history of a gradual, slow, painless enlargement of the scrotum, the translucency test, and aspiration by means of a hypodermic syringe. Before resorting to aspiration one must be sure that there is no bowel present.

Differential Diagnosis.—*Hernia.*—These two conditions often coexist, especially in cases of long standing. The sharply defined upper margin of the scrotal swelling, the absence of an impulse on coughing at the external ring and the aspiration suffice to make the differentiation.

Varicocele.—This can be differentiated from hydrocele by the enlargement of the veins which often present the so-called angleworm feel to the touch, and their failure to transmit light.

Tumors.—Hydrocele is often an associated symptom of tumor, so that one should never lose sight of this fact, especially in cases giving a history of trauma followed by a rapid enlargement of the scrotum.

Syphilis.—Hydrocele may exist with syphilis of the testis. The Wassermann test may be of value in excluding the syphilitic nature of cases under consideration for diagnosis.

Course.—The course is essentially a chronic and progressive one, so that hydroceles often reach an enormous size.

Prognosis.—Spontaneous cures are rare. Hydrocele never causes death of the patient, so that the prognosis as far as life is concerned is good. By far the greatest difficulty from which these patients suffer is the size of the hydrocele and hence an interference with their work.

Cures are sometimes seen in children following circumcision. Recurrences never follow the radical operation, and they very often recur after the injection treatment, and nearly always recur after simple tapping.

Prophylaxis.—This should consist of careful treatment of gonorrheal epididymitis and traumatism to the testes and epididymis.

Treatment.—*Tapping.*—This is a palliative measure pure and simple, for a hydrocele which has been tapped once always recurs, so that one meets patients who have had as many as twenty tappings. The free intervals gradually become shorter and shorter.

Technique.—The scrotum should be shaved and prepared as for any surgical procedure. The position of the testicle should be determined before introducing the trocar, so as to avoid injury to it. After selecting the site of the puncture, the area should be anesthetized with local anesthesia or ethyl chloride. Grasping the hydrocele with the left hand the trocar is introduced with the right hand, pushing the trocar upward and inward.

Injection of the Sac.—While this method of treatment has more cures to its credit than simple tapping, it is not as satisfactory as the operative treatment and sometimes is followed by untoward results. The objections to this form of treatment are: that it often fails to cure and that it cannot be used in cases with a thick sac wall. Recurrences are not uncommon, and the pain after the injection is sometimes very severe. Necrosis of the testicle requiring its removal has occurred.

Iodine and carbolic acid are the drugs most frequently used. Chloride of zinc, chloroform, and various other drugs have been recommended.

The Radical Operation.—The operative treatment has distinct advantages over the previously mentioned forms of treatment. When properly performed, there is no possibility of recurrence, the operation can be carried out without pain, and any coexisting lesion which might be found at the time of operation can be properly dealt with. The entire operation can be carried out with local anesthesia.

Volkmann's Operation.—After incision of the skin and dartos, the tunica is freed by blunt dissection and incised. The cut edges of the sac are sewed to the skin and the cavity swabbed out with three per cent. carbolic acid and then packed with iodoform gauze. The wound heals by granulation and requires dressings for a long time. Recurrences occasionally follow this operation.

Jaboulay's Operation.—This operation can also be carried out under local anesthesia. If the local anesthesia is properly administered, there is no pain. The incision is carried through the skin and dartos down to the tunica. By means of blunt dissection the entire hydrocele is freed. The incision into the tunica is usually several inches long and the testicle is turned out. The excess of tunica is removed with scissors and its cut edges united with catgut behind the cord. Closure of the scrotal incision with silkworm gut. Unless care is taken to stop all bleeding points, a hematoma may develop.

Wyllis Andrews has devised a modification of the Jaboulay operation. After the hydrocele has been freed, a button-hole incision, just large enough to deliver the testicle, is made in the tunica. The incision of the tunica is small and hence no suturing of the tunica is required.

Prior to each hydrocele operation one should have permission to remove the testicle should conditions be found which necessitate castration.

Should a hernia be found at operation, this should be repaired by a radical herniotomy. If an undescended testicle is present, it should be placed in the scrotum according to the method of Bevan and the accompanying hernia closed. Herman L. Kretschmer.

Hydrocephalus.—*Synonyms:* water on the brain; hydrops ventriculorum cerebri; Whytt's disease; hydranencephaly; *hydrocéphale* (French); *Wasserkopf* (German); *idrocefalo, idropsia delle testa* (Italian). The word hydrocephalus is derived from the Greek ὕδωρ, water, κεφαλή, head.

Definition.—Hydrocephalus is an abnormal, congenital or acquired, acute or chronic, accumulation of serous fluid within the cranium, the result of inflammation or obstruction.

Description.—Hydrocephalus is usually present at birth or arises in early infancy in the form of an un-

usually large and rapidly growing cranium. This may be so large as to interfere with the delivery of the child, frequently necessitating perforation of the skull. A case of hydrocephalus can rarely be mistaken for anything else. The enormous rounded cranium, with large tense fontanelles and open sutures; the scalp traversed by large veins and covered with scant hair; the relatively small face, appearing as if suspended from the cranium and tapering to a point at the chin; the eyes widely separated and bulging, with the pupils sometimes partly covered by the lower lids; the emaciated puny body, unable to hold up the enormous head or even to support itself in the sitting or standing posture; all these are characteristic of a pronounced case of this condition. There are, however, various grades in its severity. Hydrocephalus may coexist with microcephalus. Owing to premature closure of the fontanelles and sutures, and the consequent retardation in the growth of the cranium, an abnormal accumulation of fluid within the cranium may not reveal itself except through the symptoms of increased intracranial pressure which it may cause. Hydrocephalus without enlargement of the cranium may exist in later childhood or even in adult life, when the sole evidence of its presence may be increased intracranial pressure. Hydrocephalus may be associated with the various other types of maldevelopment of the cranium, such as dolichocephaly, brachycephaly, etc., or with spina bifida, encephalocele, hernia cerebri, cephalhematoma, etc. All of the above may mask or complicate the characteristic picture of hydrocephalus. The typical case can usually be recognized in the large and disproportionate size of the head, and particularly in its rapid increase in size.

Hydrocephalus is usually classified as internal or external. In the former case the excess of fluid is in the ventricles of the brain and their intercommunicating passages. In external hydrocephalus the excess of fluid is in the subdural or subarachnoid spaces surrounding the brain. This type is relatively extremely rare, being in most instances of congenital origin, the result of, or compensatory to, atrophy or maldevelopment of the brain. The term hydrocephalus *ex vacuo* is sometimes applied to this condition. Sometimes an external hydrocephalus may be the sequence of a cerebral pachymeningitis or leptomeningitis, of a cerebral hemorrhage, or of a cerebral tumor. Internal and external hydrocephalus may coexist, and they may singly or together be associated with a hydrorachis or abnormal accumulation of fluid within or around the spinal cord. When the term hydrocephalus is used alone the connotation is usually that of chronic internal hydrocephalus. At one time the expression "acute hydrocephalus" was used synonymously with that of tuberculous meningitis.

The frequency of hydrocephalus may be judged best by an examination of statistics gathered mostly in lying-in hospitals. According to R. Birnbaum, Schuchard observed one case in 753 births; v. Winckel, eight cases in 15,000 births, or one in 1,875; Kleinhans, one in 1,600; and Merriman, one in 900. During a period of twenty years in the Göttingen Women's Clinic eight cases have been observed among 4,200 births, or one in 525.

Etiology.—In discussing this subject it is necessary first of all to have a clear conception of the different types of hydrocephalus, of the location of the fluid accumulation, and of the character of the fluid itself, whether the result of a mere passive transudation or of an inflammatory exudation. Hydrocephalus has been compared with ascites, which may be the result of an obstruction to the venous return of blood from the abdominal cavity, or the result of an inflammation of the peritoneum. However, this comparison is misleading, for in a case of hydrocephalus there may be a combination of both factors, namely, obstruction and inflammation. Moreover, there must be borne in mind certain special anatomical peculiarities within the cranium such as the foramina through which the drainage of the cerebrospinal fluid is effected, and certain physiological laws governing the secretion and absorption of the cerebrospinal fluid and the equilibrium between secretion and absorption.

Parkes Weber classifies the cases of internal hydrocephalus as follows: "(1) Cases secondary to and part of the phenomena of tuberculous or any suppurative meningitis, comparable to pleural effusions due to tuberculous or any septic invasions of the pleura. (2) Cases resulting from the presence of tumors, etc., analagous to the pleuritic effusions accompanying tumors, etc., situated close to or involving the pleura. (3) Ordinary infantile or congenital hydrocephalus, which is, in some cases at least, due to intrauterine meningitis. (4) Internal hydrocephalus supervening on the epidemic or sporadic type of posterior basic non-suppurative meningitis. (5) Simple idiopathic internal hydrocephalus of adults or older children due to serous ependymitis or ventricular meningitis. (6) Traumatic cases." It is best to take up first the most common type of hydrocephalus, namely, the congenital internal variety.

Congenital Internal Hydrocephalus.—In most instances this is noticed at birth or it may be so slight as to escape attention until the rapidly accumulating fluid greatly distends the cranium. G. F. Still states that out of fifty-one consecutive cases under his observation only one began after the end of the first year (at fifteen months), and eight began between the ages of six months and one year. Thirty-two out of the fifty-one showed the hydrocephalus at birth or within the first three months of life. In at least twenty-eight of these cases the hydrocephalus was apparently of congenital origin and in fifteen of these the large head had been noticed at birth. On the basis of these figures Still concludes that fully half of the cases of hydrocephalus are of congenital origin. The head of the hydrocephalic child may be so large as seriously to interfere with delivery, when perforation of the cranium may be necessary. (See the section on the Obstetrical aspects of hydrocephalus.) Congenital internal hydrocephalus is the result of some inflammation, malformation, or maldevelopment which causes an occlusion of one or more of the foramina through which the drainage of the cerebrospinal fluid into the subarachnoid space is effected. In the first instance the inflammation is an intrauterine basal meningitis. Cautley cites the following case illustrative of maldevelopment as a cause of hydrocephalus internus. "The brain of a boy four months old was found after death to consist of medulla oblongata, pons, crura cerebri, optic thalami and cerebellum, all of which were small and ill-developed. The cerebrum was represented by a membranous bag, composed of two dilated ventricles. The aqueduct of Sylvius, where the dilatation ended, was extremely stenosed and at one spot of quite microscopic dimensions. The membrane was of the same thickness as the adult dura mater and did not seem to contain any nerve tissue elements. He came under treatment for vomiting of nine days' duration, drowsiness, occasional screaming and a variable amount of rigidity of the limbs. The head was retracted, the circumference sixteen and one-eighth inches, and showed extreme craniotabes of all the membrane bones, a large bulging anterior fontanelle, an open posterior one, and open sutures. There were rigidity of the neck muscles, general spastic rigidity of the limbs, exaggerated knee jerks, and malnutrition. The pupils were equal and reacted to light. In the course of development the anterior cerebral vesicle is di-

vided into two parts, from the center of which are developed the cerebral hemispheres with their ventricular hollows, the corpora striata, and the olfactory lobes. This portion of the brain is known as the procerebrum or prosencephalon. In the above case there was probably, in early fetal life, excessive formation of fluid in the prosencephalon and interference with its escape. Consequently it became gradually distended into a membranous bag of fluid and the nervous elements did not develop."

A conception of the origin of the fluid accumulation in the ventricles in congenital internal hydrocephalus can be gained only by a clear knowledge of the anatomical paths by which the cerebrospinal fluid is drained from the ventricles. For the following description one is indebted to G. F. Still. "The cerebrospinal fluid, in passing from the two lateral ventricles above to the theca or reservoir which surrounds the spinal cord below, has to pass by the lateral foramina of Munro into the median third ventricle, thence by the narrow iter into the fourth ventricle, which lies between the medulla and cerebellum; the fourth ventricle is closed in below by an extremely thin transparent reflection of pia arachnoid, which passes from the inferior surface of the cerebellum to the medulla; in this reflection there are three openings for the passage of the cerebrospinal fluid, a median one—the foramen of Majendie—and two smaller openings, one on each side—the foramina of Luschka—which adjoin the roots of the vagus nerves. Hydrocephalus, at least in a large majority of cases, is purely a mechanical condition, and is due to obstruction at some part of this path. In congenital cases the iter, as a result of abnormal development, may be partly or entirely absent, or its lumen may be extremely narrowed; or there may be some deformity of the cerebellum, for instance, its lobes may be elongated posteriorly, and hang down into the foramen magnum of the skull, packing this so tightly that there is no passage for the cerebrospinal fluid; or there may be cystic malformation of the cerebellum, causing it to bulge into and obstruct the ventricles; or, again, there may be adhesions between the cerebellum and medulla, perhaps as the result of some intrauterine meningitis, so that there is no exit below from the fourth ventricle. All these conditions I have myself found in congenital cases of hydrocephalus."

Some cases of congenital hydrocephalus are the result of a syphilitic meningitis of intrauterine origin, or of a fetal malformation caused by syphilitic infection in the mother. The proportion of cases of luetic origin is not known, for no studies along this line have as yet been made with the aid of modern serological methods.

Acquired Internal Hydrocephalus.—Many cases of so-called acquired hydrocephalus in which the symptoms of the disease are first manifest several months after birth are in reality instances of congenital hydrocephalus. Conversely there are cases which are regarded as of congenital origin which are really the result of an acute meningitis during the first few months of life. Most of the cases of acquired internal hydrocephalus are the result of tuberculous, meningococcic, or serous meningitis. In extremely rare instances traumatism may be a causative factor. Sinus phlebitis and the pressure of a cerebral tumor may give rise to hydrocephalus. Cases of hydrocephalus have been recorded as following the successful removal of a spina bifida or an encephalocele.

The fact that acquired internal hydrocephalus is frequently the result of an acute serous meningitis or an acute ependymitis demands a clear conception of the nature of these two conditions in order that one may understand the genesis of the ventricular accumulation. The above two terms are not synonymous, nor are they mutually exclusive. Indeed, acute ependymitis may be regarded as applying to all those cases in which there is an inflammation of the lining membrane of the ventricles, with or without inflammation of the meninges, and includes most cases of so-called serous meningitis. The latter is characterized by Quincke as meningitis serosa ventriculorum, and is also known as serous apoplexy. This may arise suddenly or gradually, in infants or in older children, and presents the various symptoms of meningitis or of so-called meningismus, from either of which it can be differentiated with great difficulty. The cerebrospinal fluid is clear and sterile and contains an increased amount of albumin, fibrin, and cells, chiefly small lymphocytes. The comparatively few cases that get well pass into a stage of chronic internal hydrocephalus, or develop symptoms that are identical with those of brain tumor. The remaining group of cases of acute ependymitis include those that are the result of an infection of the ependyma with the pneumococcus, streptococcus, influenza bacillus, etc. The inflammation may be primary, either associated with or sequent to a similar inflammation of the meninges, or secondary to a suppurative inflammation of a spina bifida or rupture of a brain abscess. These cases cannot be distinguished during life from cases of meningitis.

Acquired external hydrocephalus may or may not be associated with an acquired internal hydrocephalus. It is the result of meningitis, new growths, cerebral atrophy, marasmus, or pernicious anemia.

Morbid Anatomy.—The anatomical changes in congenital internal hydrocephalus have already been alluded to. In most of the cases that come to autopsy there is strikingly little evidence of the basal meningitis that has caused occlusion of the foramina of exit of the cerebrospinal fluid. In acquired internal hydrocephalus the anatomical evidences of a posterior basilar meningitis are more apt to be present. A new growth may be demonstrated. The association of hydrocephalus with other malformations such as porencephalus, cerebral atrophy, encephalocele, spina bifida, harelip, etc., has already been noted. The amount of fluid, which is greatest in the congenital cases, varies from a few ounces to several pints. In the acquired cases during the first four years of life the fluid only in exceptional instances exceeds eight ounces. The composition of the fluid is that of normal cerebrospinal fluid, but if the hydrocephalus is of inflammatory origin the albumin content is increased and the fluid may be turbid. In some cases the fluid is purulent. According to Cautley, "as the fluid accumulates the cerebral tissue becomes compressed and thinned, reduced to a layer only a few millimeters thick, constituting a thin wall of a vast cavity. The convolutions are flattened and eventually all trace of them is lost. The occipital region suffers less than other parts of the cerebrum. The septum lucidum is broken down or reduced to a thin membrane, and all the communications between the ventricles are greatly enlarged. The brain substance left in the cortex, if any, is pale and homogeneous, showing no differentiation into gray and white matter; and microscopical examination shows granular and broken-down nerve cells. In the worst cases only the cerebellum, pons, and basal ganglia are left, and even the basal ganglia may be almost unrecognizable. In milder degrees the ependyma is normal, or finely granular on the surface and perhaps thickened. The choroid plexuses vary." Holt states that in one of his cases the ependyma of the ventricle and the pia mater were in places in actual contact, all of the intervening brain tissue having disappeared. He also cites a case of Peterson's in which with the exception of a small portion of one temperosphenoidal lobe, all of both hemispheres had disappeared, the cerebellum and basal ganglia alone being intact. Among the results of the inflammatory process at the base of the brain there may be found occlusion of the foramen of Munro and of the aqueduct

of Sylvius; and occlusion of the foramina of Lushka (the aperturæ laterales ventriculi quarti) and thrombosis of the venæ Galeni. Cautley points out that if both veins are thrombosed death results from cerebral anemia before hydrocephalus can develop. Obstruction of any of the above foramina, of the third or fourth ventricles, or of the aqueduct may be caused by the pressure of a tumor.

It was at one time maintained that hydrocephalus is the result of a disturbed function of the choroid plexuses which secrete the cerebrospinal fluid. This explanation which seemed to account for those cases particularly in which no evidence of any obstruction could be found, was first advanced by Barlow and Lees. They pointed out that each ventricle is provided with its own vascular plexus, those in the lateral ventricles having a double arterial supply. Moreover the epithelium covering these plexuses has a structure similar to that of a secreting epithelium. Barlow and Lees believed that a paretic condition of the basilar artery and of its branches resulting from some previous inflammation causes an excessive supply of blood to the choroid plexuses, with the consequence that the cerebrospinal fluid is secreted more rapidly than it can escape through the various foramina. Still notes that this hypothesis of the loss of balance between secretion and absorption rests merely on conjecture and is incapable of proof.

Symptoms.—In the congenital types of hydrocephalus the child may die *in utero* or its head may be perforated in order that delivery may be effected. The symptoms may be wholly or partly present at birth or may be of gradual onset during the first few months of life. In a large proportion of the cases nothing unusual or possibly only a slightly enlarged cranium is noticed at birth. In the second or third month attention is attracted by the rapidly increasing size of the head. The other symptoms arise sooner or later, depending upon the rapidity of the effusion. In the acquired types of hydrocephalus the symptoms may appear during any period of infancy or childhood or even in adult life, immediately after recovery from an attack of epidemic meningitis, or in the course of a serous, a basilar, or a tuberculous meningitis, or of the development of a brain tumor, and are of gradual onset. The symptoms are those arising from the gradual expansion of the cranium, and from pressure upon the brain, or if the ventricular accumulation occurs after ossification of the sutures, the symptoms may be those caused by cerebral pressure alone. The chief manifestation is the enlargement of the cranium which is characteristic. The expansion of the cranium is globular, as distinguished from the squarish and bossy enlargement of rickets. The diameters are not uniformly increased, the anteroposterior and the vertical ones being chiefly affected. The vertical diameter is increased out of all proportion to the anteroposterior diameter, and there is considerable bulging in the frontal region. In some instances the cranium has a pyramidal conformation. As a rule, the enlargement is not symmetrical, particularly if the infant lies habitually on one side. Cases have been reported in which the distention was limited to one side of the cranium, or to a part of the latter corresponding to one or more bones, or in which the anterior portion of the cranium was increased out of all proportion to the posterior portion. In all cases of hydrocephalus there is a pronounced bulging at the root of the nose, a characteristic which is not observed in any other form of cranial enlargement. The increased size of the cranium may be scarcely perceptible or it may be enormous. The sutures are widely separated, and the fontanelles are greatly enlarged and fail to close, and in the cases that survive remain in this condition until late childhood. The anterior fontanelle may be so large as to extend forward to the bridge of the nose and backward to the posterior fontanelle. There is also considerable tensity and bulging of the fontanelles, the degree of which is commensurate with the amount of intracranial tension. Fluctuation may also be elicited by palpation of the fontanelles. The sutures may be separated as widely as three inches. The exact degree of cranial enlargement may be gauged by comparison with the normal size of the cranium at any particular age. According to the observations of Still, the maximum circumferences at various ages are the following: Birth, thirteen inches; three months, fifteen inches; five months, sixteen inches; nine months, seventeen inches; twelve months, eighteen inches; three years, nineteen inches; seven years, twenty inches; thirteen years, twenty-one inches. In hydrocephalus the circumference may be twenty inches at three months, twenty-two inches at one year, and twenty-four inches at five years. The largest circumference ever observed by Still was one of thirty-eight and one-half inches in a case of congenital hydrocephalus at nine weeks. Indeed the congenital cases are the ones in which the greatest degrees of cranial expansion are found. The rate of increase in these cases is usually about one-quarter of an inch a week; in some instances it may be as much as one inch per week. After the age of six months the rate of increase gradually diminishes. According to Still, the increase in the second year is often at the rate of about one-half inch in three months, and in the third year about an inch in twelve months. In cases that run a favorable course the rate of increase slowly diminishes until the age of five or six years when the fontanelles and sutures are closed. After this period the rate of increase slightly exceeds the normal for the age.

As the result of the extreme enlargement of the cranium and the greatly increased intracranial pressure, the bones of the cranium are more or less thinned out and may show patches of craniotabes; the skin of the scalp is greatly stretched and thinned; the hair is scant owing to the tensity of the scalp and the consequent interference with the nutrition of the hair follicles; and the veins of the scalp, partly because of the thinning of the latter and partly because of the increased tension within the cranium and the development of a collateral circulation are quite prominent and frequently appear to lie in grooves on the cranial bones. In some cases it may be possible to obtain transillumination of the cranium. The face is of a triangular shape and is relatively small. The bridge of the nose is broad and flattened. The appearance of the eyes is characteristic. The orbits are widely separated from each other and the eyeballs bulge forward and are rotated downward, as the result of flattening of the roof of the orbit. The downward rotation of the eyeball may be so extreme that the pupil may be partly hidden by the lower eyelid, so that the infant in order to see is compelled to pull its lower eyelids downward with the fingers. The sclerotic above the cornea is often exposed. The downward rotation of the eyes is such an early symptom of hydrocephalus that Still finds it difficult to suppose that this rotation is due to direct pressure. In the early stages the pupils are usually small and equal, and later become dilated and immobile. There may be present strabismus, nystagmus, myopia, hemianopia, or blindness. The last may result from pressure of the dilated third ventricle upon the optic tracts and chiasma. According to Still, optic neuritis is almost never seen with congenital hydrocephalus; the presence of optic neuritis almost always points to cerebral tumor as the cause of the hydrocephalus. Choroidal changes are found in some cases.

As the result of the pressure of the greatly dilated ventricles upon the substance of the brain, there result all the degrees of mental impairment. In the mild cases of hydrocephalus there may be no mental manifestations. In fact, in some instances the intelligence of the infant may be above the

normal. If the fluid accumulates slowly and especially if the cranium expands readily, a considerable degree of hydrocephalus may be attained and yet there may be no mental defect whatever. Indeed, there is a tradition that children who have recovered from hydrocephalus later evince a mental activity above the normal owing to the fact that the brain has more room in which to develop. The average infant suffering from hydrocephalus is lethargic and placid. In the cases with an extensive effusion there may be apathy, stupor, and coma. Convulsions occur in one-third of the cases, with equal frequency in the congenital and acquired types of the disease. Various types of paralysis may be present and there may be a spastic condition of the limbs. There is a considerable amount of physical weakness. In many of the cases the presence of headache is indicated by the fact that the infant holds its hands up to its head at the same time that it cries or whines. The peculiar "hydrocephalic cry" is said to be also characteristic of cases of tuberculous meningitis. The infant cannot, as a rule, hold up its head partly because of the weight of the latter and partly because of the muscular weakness, and in many cases cannot sit up or stand at the usual period. The inability to stand may be the result of the general muscular weakness, of paralysis, of a spastic condition of one or both legs, or of the general mental retardation. In the cases that survive or recover walking is usually delayed until the third or fourth year. In the pronounced cases there are defects in the special senses. The ocular manifestations have already been described. The mental impairment may be slight or may be one of imbecility or idiocy. The growth of the body is retarded. The digestion, as a rule, is good but in many of the cases there are nutritional disturbances. The vital resistance is weakened and the infant falls a ready prey to infectious disease. In cases in which there are symptoms of cerebral compression the pulse is slow and irregular. There may be a persistently subnormal temperature.

In cases of so-called concealed hydrocephalus in older children or in adults in which closure of the sutures and fontanelles prevents expansion of the skull, the symptoms are solely those of increased intracranial pressure, namely, headache, vomiting, and optic neuritis. These symptoms may be of acute onset, or they may be protracted over a considerable period of time. To quote Cautley: "Intense, paroxysmal headache may cause sudden death. Persistent malnutrition, retarded development, peculiarities of temper, morals or emotions, incontinence, palsies, convulsions, and insanity may be noted. In others there are fine tremors of the tongue, lips, and hands; slight exophthalmos; weakness of the lower limbs; optic neuritis, and fluctuating facial or ocular palsies. Cases of this type, when a sequel of effusion in earlier life, generally have an enlarged cranium and are often called chronic hydrocephalus. Retraction of the head, partly from the weight and partly from basal irritation, inability to support the head, vomiting, irregular fever, twitchings, and convulsions may be present, if the fluid is increased or if there is continued basal irritation. Sudden attacks of headache, vomiting, and fever are due to exacerbations of the basal mischief or increased effusion." If hydrocephalus arises in the course of a serous or of a tuberculous meningitis the symptoms caused by the pressure upon the brain substance of the effusion within the ventricles may be indistinguishable from those of the primary disease. Indeed in all cases of meningitis in which lumbar puncture shows an increased tension of the cerebrospinal fluid, one is justified in stating that a certain degree of hydrocephalus is present. The presence of tympany on percussion over the region of the lateral ventricle (Macewen's sign) indicates distention of the ventricle with an increased amount of cerebrospinal fluid.

Course and Prognosis.—In the congenital type of hydrocephalus the disease is chronic and progressive and terminates fatally usually before the first year of life, most frequently during the first six months. In these cases the evolution of the disease is a rapid one; the symptoms of cerebral irritation and compression appearing at an early stage, and increasing in severity from day to day. Death occurs from bodily wasting, inanition, convulsions, intercurrent disease, and in extremely rare instances from rupture of the cranium. In the cases which develop slowly, and if the disease begins before the sutures are ossified, the cranium expands gradually, though at a greater rate than in a normal child. The cerebral symptoms may be few or wanting. If, however, the disease arises after the sutures have united the symptoms of increased intracranial pressure develop rapidly and may cause death within a short time. Many cases in which the disease begins in later infancy or early childhood live for four to six years. In most cases periods of remission of symptoms occur. In rare instances the effusion may be arrested, and the child may then continue to develop normally and attain adult life, the only relic of the disease being the large head. A few cases have been reported in which there occurred a spontaneous evacuation of cerebrospinal fluid from the nose with temporary or permanent relief of the symptoms.

Diagnosis.—In the great majority of cases the diagnosis is not difficult. The globular head of a case of hydrocephalus is easily distinguished from the rachitic head which is flattened on top and somewhat square in outline. Moreover, in rickets the sutures are closed, and the anterior fontanelle, although large, is not bulging and has thickened edges. In rickets there are frontal protuberances but in hydrocephalus the entire frontal region exhibits marked bulging. It is possible for rachitis and hydrocephalus to coexist, in which event the characteristics of both conditions may be present. The theory that all cases of rickets are complicated with a certain degree of hydrocephalus has not been substantiated. If hydrocephalus arises after closure of the fontanelles and ossification of the sutures the diagnosis may be difficult, for it is necessary to rule out brain tumor, intracranial hemorrhage, or any other condition giving rise to increased cerebral pressure. As already mentioned Still has noted that optic neuritis is practically never seen in congenital hydrocephalus. The presence of optic neuritis in a case of hydrocephalus points to the existence of a cerebral tumor as the cause of this condition. There is an extremely rare condition known as "hypertrophy of the brain" in which enlargement of the cranium occurs as the result of overgrowth of the neuroglia of the brain. In this condition, as in hydrocephalus, there are evidences of mental deficiency, but in the former the growth of the cranium is not rapid as in hydrocephalus. Indeed, the rapidity of enlargement of the cranium is the most important diagnostic point in the average case of hydrocephalus. An increase in the circumference of the skull of an inch a month is conclusive evidence of the existence of hydrocephalus. The thickenings of the cranial bones sometimes observed in tertiary and more rarely in congenital syphilis need cause no confusion in the differential diagnosis from hydrocephalus. Similarly the localized hypertrophy of the cranial bones seen in leontiasis ossia should be borne in mind as a possible condition in an exceptional case of cranial enlargement.

Treatment.—In the large majority of cases of this condition the treatment is unavailing. Many measures, both medical and surgical, have been given a fair trial, but the results on the whole have not been encouraging. The mild cases get well without or in spite of treatment. Inasmuch as hydrocephalus is secondary to any of a number of pathological conditions, the treatment is bound up with that of the

latter. In no instance, except in the cases that are very severe from the beginning can one foretell that the hydrocephalus may not be of a mild type or may not eventually be arrested. Inasmuch as there may be a syphilitic substratum, and particularly if the Wassermann reaction is positive, a fair trial should be made of the mercurial preparations. Gray powder in doses of one-half grain may be administered twice a day. One-half dram of mercurial ointment may be rubbed into the scalp every day. Iodide of potassium should be given at the same time. The efficacy in this condition of salvarsan or neosalvarsan has not yet been demonstrated, nevertheless either of these preparations deserves a trial. The method of treatment by means of tight bandaging of the head, which method was in vogue at one time, has been wholly abandoned. Recently Somma has recommended the trial of heliotherapy, the head of the infant being exposed to the direct rays of the sun for from fifteen to thirty minutes daily. Lumbar puncture is a measure of definite usefulness; if not curative in rare instances, it is at any rate a means of relieving symptoms. It may be performed every three days at first, then once a week, and later at longer intervals. The frequency of this operation is to be determined by the intensity of the symptoms and by the rapidity with which the cerebrospinal fluid reaccumulates. The amount of the latter to be withdrawn at each time is likewise to be determined by the severity of the case and by the effect of the operation upon the general condition of the child. The amount of fluid removed may be from one to one and a half ounces. The effect of this operation in the reduction of intracranial pressure is perceived in the fact that a bulging fontanelle becomes a depressed one. In many instances the happy effect of lumbar puncture is immediately noticed. An infant that has been in profound stupor or coma may shortly after lumbar puncture notice its surroundings and be able to take nourishment. McCaw states that improvement has followed the injection of normal horse-serum or of a 0.5 per cent. solution of protargol into the cerebrospinal canal. He also states that absorption of the excessive cerebrospinal fluid has followed the injection under the skin of fluid obtained from a pleural effusion.

As a substitute for and possibly as an improvement over lumbar puncture, direct tapping of the lateral ventricles has been frequently recommended within recent years. This procedure is known as ventricular puncture, and if properly carried out entails no risk to the child. In view of the fact that this is the simplest of the various operations that have been devised for the direct drainage of the lateral ventricles, and also in view of the fact that it is within the reach of the general practitioner, a detailed description of this operation will not be superfluous. This description is given by L. Bathe Rawling as follows: "This operation may be carried out through the anterior fontanelle, through the frontal bone, or over the descending cornu of the lateral ventricle.

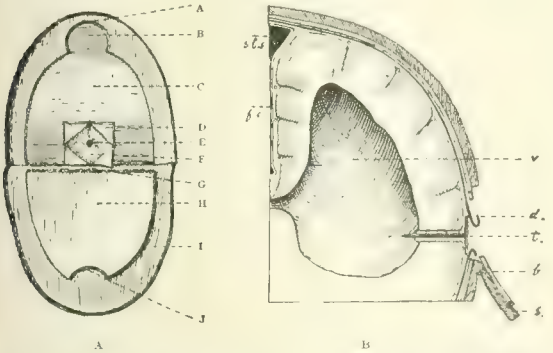
"*Through the Anterior Fontanelle.*—The region of the fontanelle is shaved and cleansed in the usual manner, after which the surrounding parts are cut off from the field of operation by a large sheet of gauze or lint, in which a hole is cut sufficing to allow of exposure of the site of election for puncture. The patient should be in the recumbent position, the head well toward the end of the table. The operation is performed without an anesthetic or under local anesthesia. A site is chosen at the outer angle of the fontanelle, about one inch away from the median anteroposterior line, thus avoiding all possibility of injuring the superior longitudinal venous sinus. The trocar and cannula, of small size, are passed directly inward, toward the base of the skull, for a distance of not more than two inches. The trocar is withdrawn and the fluid allowed to escape slowly. If the cerebrospinal fluid escapes at high pressure, the flow should be regulated by the finger placed over the mouth of the cannula, and, in any case, it is inadvisable to allow of the withdrawal of more than 50 c.c. (approximately one and one-half ounces) at one sitting. The cannula is withdrawn and the site of tapping covered with collodion gauze. Even when adopting all precautions the operation is not without danger, and added to this is the fact that few surgeons care about introducing an instrument blindly into the cerebral cortex—the risk of puncturing one of the distended superficial cerebral veins is sufficiently obvious.

"*Through the Frontal Bone.*—Tillmanns, in recommending this procedure, states that the needle should be inserted about two centimeters from the central line and three centimeters from the precentral sulcus. You strike the ventricle at a depth of from three to five centimeters. He claims that this method leads to satisfactory results. It is open, however, to all the objections of puncture through the fontanelles.

"*Over the Descending Cornu of the Lateral Ventricle.*—This operation is strongly recommended by Keen on the ground that excellent drainage is supplied. A point is mapped out on the skull which lies one and one-fourth inches behind the external auditory meatus and the same distance above Reid's base-line. If the posterolateral fontanelle be open a small trocar and cannula may be introduced at the upper angle of the space—thus avoiding the lateral sinus—and passed inward in a direction toward the summit of the opposite ear. If the fontanelle be closed, a scalp-flap is framed and a bone disc removed with a one-fourth to one-half inch diameter trephine. The dura should be opened. The evacuating instrument is then introduced through the membrane in the same direction as before. In either case it should not be passed for a greater distance than one and one-half inches, and, in all cases, the exploration should be of a progressive nature, that is to say, the trocar should be withdrawn once for each one-half inch of brain substance perforated. The escape of cerebrospinal fluid must be regulated in the manner previously described. If trephining has been necessitated, the bone disc is not replaced, thus allowing of subsequent tappings through the trephine hole, this gap now taking the place of a patent posterolateral fontanelle. Keen's method of ventricular puncture presents many advantages over other methods, though still open to the objection that the actual central puncture is done blindly."

Rawling has devoted considerable attention to the surgical treatment of hydrocephalus and notes that whereas in only rare instances has any material benefit resulted, there is a possibility that better results will be obtained in the future. The most promising results are said to be obtained by the operation of ventriculo-subdural drainage, which is regarded as subjecting the patient to the least risk. This operation is performed by Rawling as follows: "A point is mapped out on the scalp which corresponds to the surface-marking of the descending horn of the lateral ventricle, and, with this point as a guide, a scalp-flap is framed, the base of which lies immediately below the indicated spot while its convexity is situated between one and one-half and two inches above. This flap should not include the pericranium. The flap is turned down to its base, the pericranium stripped aside and a disc of bone removed, at the upper part of the exposed bone, with a one-fourth or one-half inch diameter trephine. The bone is usually very thin. When this disc is removed, the dura is separated from the bone, and, with the aid of a strong pair of scissors, the bone is cut in such a manner as to form a bone-flap, the margins of which lie well within those of the scalp-flap. This flap is broken across at its base, turned down, and covered with gauze. At the lower portion of the exposed dura mater, a crucial incision is made through the dura

mater and a blunt-pointed trocar and cannula introduced at the center of the exposed brain, all visible vessels being avoided. The diagnosis is now confirmed—by the withdrawal of the trocar and the escape of the cerebrospinal fluid. By the introduction of a bundle of horsehair or catgut, passed through the cannula so as to project into the ventricular cavity, and, after the withdrawal of the cannula, tucked, with respect to the proximal ends, into the subdural, extradural, or subaponeurotic spaces, it is obvious that drainage may be established between the ventricles and the other regions. Experience showed, however, that drainage into the subaponeurotic space usually converted the condition of hydrocephalus into one of cephalocele, the fluid collecting as a localized fluid tumor over the region of exploration, while extradural drains did not permit of sufficiently rapid reabsorptions of fluid. Subdural drainage gave the best results, the cerebrospinal fluid being brought into relation with the pia-arachnoid meshwork of vessels. It would, of course, be infinitely preferable if the ventricular fluid could be brought into direct relation with the veins of the subarachnoid space, for the cerebrospinal tension and venous pressure are equal, and all excess of cerebrospinal fluid would be absorbed as soon as it is formed. This course is, however, impossible to carry out. We have, therefore, to rest content with less direct contact, drainage into the subdural space. This ventricular-subdural drainage, as obtained by horsehair, catgut, and silk, apparently leads to but tem-



A B

Fig. 3300.—Diagrammatic Representation of Rawling's Operation for Hydrocephalus Internus. *A*, The osteoplastic exposure of the brain; *A*, the bone; *B*, upper two-thirds of trephine hole; *C*, dura mater; *D*, the four dural flaps; *E*, site of brain perforation; *F*, the brain; *G*, line of fracture of bone-flap; *H*, the bone-flap; *I*, the scalp; *J*, lower third of trephine hole; *B*, Ventriculosubdural drainage; *s*, the scalp; *b*, the bone; *d*, the dura mater; *v*, the lateral ventricle; *t*, the drainage medium between the ventricular cavity and the subdural space; *s.l.s*, superior longitudinal sinus; *f.c*, falx cerebri. (After Rawling.)

porary benefit, probably owing to falling together of the brain substance and obliteration of the adventitious passage. Silver tubes and bone tubes have been utilized. The tube was cut across in an oblique manner at about its center, the two parts set at right angles to one another and sewn together with silk. One arm is introduced into the ventricle, the other tucked underneath the dura mater. The child improved considerably but the method is not altogether satisfactory and by no means easy of application. In another case I utilized strands of silver wire. The depth of brain tissue necessary to reach the ventricular cavity was measured, and two or three strands of wire introduced so as to project well into that space, then steadied with forceps while the proximal ends were bent at right angles to the surface of the brain and tucked underneath the dura mater. The method was unsatisfactory. Tubular drainage is not essential, for the fluid escapes from the ventricle as much along side the tube as through its lumen. Still, I believe that tubular drainage is preferable to other methods, and, realizing the difficulty of introducing a right-angled tube—one arm to project into the ventricle, the other to lie beneath the dura mater. Messrs. Arnold & Son are now making for me small and light right-angled silver tubes so constructed that each limb can be inserted independently, after which they can be locked together. This method appears to overcome many of the difficulties previously encountered. The tube is inserted after the formation of the osteoplastic flap, as described above. The four dural flaps are then united, preferably by cross union of their apices, the bone flap is replaced, and the scalp flap sewn accurately into position. Collodion gauze, applied to the wound, aids in the prevention of cerebrospinal escape. The scalp and bone flaps are framed, and the dural incision carried out low down, so as to make the opening to the brain as valvular as possible. All these precautions are taken to avoid leakage of cerebrospinal fluid, a most troublesome complication—adding to the risk of infection and often resulting in an acute eczematous condition of the surrounding skin. By this method it is hoped that a permanent fistulous communication will be formed between the lateral ventricle and the subdural space."

In addition to ventriculo-subdural drainage, other methods of creating an artificial outlet for the cerebrospinal fluid have been resorted to. These methods have sought to drain this fluid into the cellular tissues of the scalp or of the lumbar region; into the retroperitoneal space or abdominal cavity; into the jugular vein; and even into the pleural cavity. An operation has been devised by Harvey Cushing in which it is sought to effect drainage of the cerebrospinal fluid into the peritoneal cavity. This operation which is known as ventriculo-abdominal drainage has been performed by Cushing with apparent success in twelve cases. It is described as follows: "It having been established that the ventricle can be emptied by the lumbar route, and that the withdrawal of fluid is not prejudicial to the child's well-being, the following procedure is carried out. A laparotomy is performed; the posterior layer of peritoneum to the left of the rectum is split; the body of the fifth lumbar vertebra, just under the bifurcation of the velles is exposed; the bone is trephined and one-half (the female portion) of a silver cannula, exactly the size of the trephine, is inserted and held in position. The child is then turned on his face and a laminectomy performed; the subarachnoid space is opened, the strands of the cauda separated, and the posterior half (male portion) of the cannula is invaginated, so that it locks into the portion inserted anteriorly. Both wounds are then closed. The fluid for a time finds its way into the peritoneal cavity, but ultimately into the retroperitoneal space whence it is taken up by the receptaculum chyli, as experimental observations have shown."

Cotterill has performed the following operation for the purpose of reestablishing drainage from the ventricle: "A large semilunar flap is made from the occipital region, exposing the bone. Trephine circles are made on either side of the median ridge, and the intermediate part of the bones, together with the posterior part of the foramen magnum, is removed. The dura mater is opened and the occipital sinus ligatured. The lateral lobes of the cerebellum are then held apart, and the thickened arachnoid over the posterior part of these lobes and over the roof of the fourth ventricle exposed. This roof is opened. The wound is then closed." C. H. Frazier states that ligation of both common carotid arteries at intervals of ten days or two weeks has been recommended upon the ground that, by diminishing the flow of blood to the brain, the secretion of cerebrospinal fluid will be materially diminished. Frazier has practised this method in one instance with gratifying results. If there are headache, vomiting, and choked disc, relief may be afforded by temporal decompression.

H. S. Pendlebury has devised an operation in which it is sought to effect drainage of the lateral ventricles by means of a heavy silk thread introduced by means of a long needle from outside the cranium into the lateral ventricles. The ends of the thread are inserted beneath the scalp and then beneath the skin of the back of the neck. The procedure is the same as in the operation for lymphangioplasty described by Sampson Handley. The silk connects both ventricles with each other and with the connective tissue of the neck. The results of this operation are said to be most encouraging.

Obstetrical Aspects of Hydrocephalus.—The excessive size of the head of a hydrocephalic fetus usually interferes with delivery. Failure to recognize this condition may result in rupture of the uterus, hemorrhage, or septic infection. Spontaneous delivery is possible only in the case of slight degrees of hydrocephalus, or after maceration of the fetus, or after spontaneous rupture of the cranium. Such rupture has occurred most frequently in breech presentations. Most of the cases of hydrocephalus present by the head. Birnbaum states that hydrocephalus of moderate degree is most to be feared, as in this instance the head does not engage in the pelvis. The diagnosis is made by recognizing the gaping fontanelles, the wide sutures, the enlarged head, and in some cases the parchment crepitation of the greatly thinned cranial bones. Hydrocephalus may be suspected if the head remains above the brim although the pelvis is normal in size and there is no other apparent interference with delivery. The treatment of labor obstructed by hydrocephalus is puncture of the cranium with a perforator and evacuation of the fluid. The labor may then be left to the natural forces, but if these prove insufficient a cranioclast may be fastened to the skull and the child be extracted artificially. Hirst points out that a cardinal rule in these cases is to avoid any attempt to deliver with forceps—a common error in practice, causing rupture of the uterus and deep tears from slipping of the instrument, with extensive sloughs after delivery. In the case of breech presentation if the head is inaccessible above the superior strait, the spinal canal may be opened, a catheter may be passed through it into the cranial cavity and the fluid then evacuated (Van Huevel's method). Usually, however, the force of extraction ruptures the walls of the ventricles, and converts the case into one of external hydrocephalus, or drives the fluid out of the foramen magnum into the tissues of the neck and back. The head may then be punctured through the roof of the mouth, through the foramen magnum, or behind the ear.

Alexander Spingarn.

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Hydrochloric Acid.—Under the title *Acidum Hydrochloricum*, Hydrochloric Acid, the United States Pharmacopœia recognizes "a liquid composed of 31.9 per cent., by weight, of absolute hydrochloric acid, and 68.1 per cent. of water." Such grade of acid is "a colorless, fuming liquid, of a pungent odor, and an intensely acid taste. Specific gravity: about 1.158 at 25° C. (77° F.). Miscible, in all proportions, with water or alcohol" (U. S. P.) It was formerly known as muriatic acid. Hydrochloric acid must be kept in glass-stoppered bottles and protected from the light.

The physiological effects and therapeutic applications of hydrochloric acid so closely resemble those of nitric acid that a separate description is unnecessary (see *Nitric Acid*). For medicinal use, proper, the following official preparation is established by the United States Pharmacopœia:

Acidum Hydrochloricum Dilutum. Diluted Hydrochloric Acid.—This preparation is a simple dilution of the strong acid of the Pharmacopœia with distilled water. It represents ten per cent. of absolute hydrochloric acid, is a colorless and very sour fluid, irritant though not corrosive, and of the specific gravity 1.049 at 25° C. (77° F.). Dose, from ten to thirty drops, largely diluted with water and the mouth to be rinsed well after the taking of each dose.

Edward Curtis.
R. J. E. Scott.

Hydrocyanic Acid.—Hydrocyanic, or, as it is so commonly called, *prussic* acid (HCN), is, in pure or anhydrous condition, a thin, colorless, very volatile, very unstable, and exceedingly poisonous fluid. Being so unmanageable in the concentrated state, the acid is used in medicine only in dilute solution in water or in alcohol and water. "Since the first introduction of hydrocyanic acid into the Materia Medica by Borda in 1804, it has been used in degrees of concentration varying from 1 to 50 per cent. Robiquet's acid was 50 per cent.; Koller's, 25 per cent.; Ittner's, Pfaff's, and that of the French Codex, 10 per cent.; Duflos', 9 per cent.; Scheele's, 4 to 5 per cent.; that of the Pharm. Bavar., 4 per cent.; Vauquelin's and that of the Edinburgh Pharm., 3.2 to 3.3 per cent.; that of the Dublin Pharm. 1.6 to 2.82 per cent.; those of the United States and British Pharm., 2 per cent.; Schrader's, 1.5 per cent.; and that of the Prussian Pharm., 1 per cent. At the present time the medicinal acid dispensed in the United States is invariably intended to be the U. S. P. acid; while in England both the Br. Ph. and Scheele acids are used" (Witthaus' *Toxicology*). Under the title *Acidum Hydrocyanicum Dilutum*, Diluted Hydrocyanic Acid, the United States Pharmacopœia establishes "a liquid composed of not less than two per cent., by weight, of absolute hydrocyanic acid, and about ninety-eight per cent. of water." This preparation may be prepared extemporaneously by the following process, officially authorized: "Silver cyanide, 6 gm.; diluted hydrochloric acid, 15.54 c.c.; distilled water, 44.10 c.c. Mix the diluted hydrochloric acid with the distilled water, add the silver cyanide, and shake the whole together in a glass-stoppered bottle. When the precipitate has subsided, pour off the clear liquid." In this process double decomposition ensues between the silver cyanide and the hydrochloric acid, with the formation of hydrocyanic acid which remains in solution, and silver chloride which precipitates.

Diluted hydrocyanic acid is "a colorless liquid, of a characteristic odor, resembling that of bitter almonds. On account of its poisonous character *it should be tasted with great caution.* It is completely volatilized by heat" (U. S. P.). The acid is more or less prone to decompose, thereby losing strength, and in such decomposition commonly turns dark, even getting

in time to look like a thin ink. This decomposition will certainly and rapidly go on under exposure to the air in an open vessel, and is also hastened by the action of light. The preparation must, therefore, be put up in small, dark, amber-colored vials and kept in a cool place protected from the light. An important point is to have the vials *cork*-stoppered, and not *glass*-stoppered, since, for some reason, the preparation deteriorates much faster in glass-stoppered bottles than in those closed by cork. The acid will keep better, furthermore, according to Squibb, if, in dispensing, quantities be drawn from the stock bottle by a pipette instead of by pouring.

Physiologically, hydrocyanic acid is remarkable for deranging, swiftly and strongly, the functions of nerve apparatus, apparently irritating and quickly exhausting certain nerve centers, and also tending to destroy the conducting power of nerves and the contractility of muscles generally. Probably by virtue of these actions, hydrocyanic acid is a peculiarly speedy and powerful poison.

The application of hydrocyanic acid in *therapeutics* does not amount to much. By reason of its poisonous nature, the medicine can be used only in insignificant doses, and the only medicinal virtues that such doses possess are to allay pain or irritability of the stomach, and, less certainly, the irritability of the air passages in disease that leads to dry cough. The local use of hydrocyanic acid solutions as lotions in skin disease, to allay pain and itching, is not without danger of inducing constitutional poisoning by absorption through unobserved abrasions.

Hydrocyanic acid in the form of the dilute solution of the United States Pharmacopœia is commonly prescribed in doses of from one to two minims only, but this dosage may be gradually increased; when the prescription is renewed the dosage should again begin at one or two minims. Furthermore, since the effect of the drug is very evanescent, and there is no evidence of any so-called cumulative action, there is no objection, physiologically, to the repetition of even a full dose so often as every hour. The dose may be administered in water, or syrup and water, and may be combined with alkaloidal salts, but not with salts of the metals. For a skin lotion, the pharmacopœial acid is variously diluted from ten- to fifty-fold by different practitioners.

EDWARD CURTIS.
R. J. E. SCOTT.

Hydrocyanic Ether.—This body, chemically *ethyl cyanide*, $C_2H_5.CN$, is a colorless ethereal fluid miscible with water, alcohol, and ether, and possessed of poisonous properties analogous to those of hydrocyanic acid. It is not used in medicine.

EDWARD CURTIS.
R. J. E. SCOTT.

Hydrogen Dioxide.—Hydrogen dioxide, H_2O_2, commonly called *peroxide of hydrogen*, is formed by reaction between barium dioxide and mineral acids in the cold. Obtained in concentrated condition, this body appears as a colorless, transparent, heavy, oily fluid, of specific gravity 1.452, neutral to test paper, remaining fluid at temperatures far below the freezing point of water, but rapidly and even explosively suffering decomposition into water and gaseous oxygen upon even a slight elevation of temperature, or upon contact with charcoal and certain metals and oxides. Even at ordinary temperatures the same decomposition occurs spontaneously to a greater or less extent.

Hydrogen dioxide mixes in all proportions with water and dissolves also in ether. As a medicine, it is used in solution in one or other of those fluids, the aqueous solution being commonly known as *oxygenated water*, and the ethereal as *ozonic* or *ozonized ether*. The *aqueous* solution in common use contains three per cent. of hydrogen dioxide by weight, a strength representing a charge of ten volumes of oxygen to one of the water of the solution. Such a solution is official in the United States Pharmacopœia under the title *Aqua Hydrogenii Dioxidi*, Solution of Hydrogen Dioxide. It contains a little sulphuric acid, purposely allowed to remain, as a preservative, from the charge of acid used to clarify the solution. This solution is a sparkling, clear, colorless aqueous fluid, odorless, but having an acidulous and disagreeable chlorinous taste, and producing a curious sensation and a soapy froth in the mouth, through evolution of oxygen. Its specific gravity ranges from 1.006 to 1.012 at ordinary temperatures. It tends to decompose spontaneously into water and oxygen, and accordingly will deteriorate by age, especially if exposed to light or to warmth. If subjected to evaporation at a temperature not exceeding 140° F. the solution will gain in strength through loss of water, but if heated rapidly it is liable to decompose at once and with explosive violence. Because of these various properties, the solution should be kept in dark amber-colored bottles, *loosely* stoppered and in a cool place. A tight stopper may be blown violently from the bottle, or the bottle itself may be burst, if the stopper be immovably seated. Furthermore, since deterioration by keeping is inevitable, a freshly made sample should be procured always, when possible, for use. Old specimens will certainly be under standard in strength, and even may be wholly spoiled and inert. The Pharmacopœia states that if the stopper in the bottle be replaced by a pledget of cotton, deterioration is retarded.

Solution of hydrogen dioxide is neither corrosive nor poisonous, and is irritant only to especially sensitive parts, such as the eyes, the urethra, or raw surfaces. Its use in medicine is because of its ready decomposition, with yield of free oxygen. Such decomposition is determined by mere contact of the solution with many things, among which are the organic matters found in blood, mucus, pus, and other morbid discharges, diphtheritic membrane, the bodies of pathogenic microorganisms, and decaying organic substances generally. It coagulates albumen powerfully. By virtue of the yield of oxygen the solution destroys, by oxidation, the morbific quality of animal secretions and excretions. When added to pus, brisk effervescence ensues and the pus corpuscles are quickly disintegrated. Similarly, when washed over a secreting surface, frothing occurs, crusts of dried secretion are loosened, and foul odors disappear. The foaming will continue till all adhering pus or mucopus is destroyed, when, after washing, the surface will be found to be perfectly cleansed and of healthy appearance. Solution of hydrogen dioxide is thus powerfully detergent and disinfectant to all styles of morbid surface conditions, whether of skin, mucous or serous membrane, or wounds or ulcers. The action, however, is evanescent and does not seem to include any intrinsic healing virtue, such as is shown by silver nitrate. For ordinary purposes, the pharmacopœial ten-volume solution may be used in full strength, but for application to sensitive surfaces such as the eye, the upper nasal passages, or the urethra, it should be diluted with from one to four or more parts of water. Hydrogen dioxide should not be injected into a suppurating cavity unless there is a free outlet for the escape of the gas which is produced. It may be applied by swabbing, by injection, or by spraying, but only instruments or utensils of hard rubber, glass, or porcelain should be allowed contact with the solution. To affect the surfaces of the stomach or intestines the solution may be given, without fear, by swallowing or by enema. From one to two or three teaspoonfuls may be given

at a dose by the mouth. This dose should be well diluted with water and taken from a vessel of porcelain or glass. Other medicines should not be combined with the solution.

Attempts have been made to utilize the solution of hydrogen dioxide as an oxidizing agent within the system for the cure of disease. But when given by swallowing, a dose of the solution is almost wholly decomposed in the stomach, and, when administered hypodermatically, similar decomposition takes place at once in the juices of the part receiving the charge. In either case, therefore, but little of the solution can enter the blood unchanged, so that there is at best but small chance for a constitutional effect of any moment. If injected into the veins, the solution is instantly decomposed by the blood, and, in cases in which this procedure has been tried upon animals, it has often been followed quickly by death from embolism, due to coagulation of the blood by the disengaged oxygen.

Aqueous solutions of hydrogen dioxide stronger than that of the Pharmacopœia are to be found in the market (so-called "hydrozone"), and also solutions with glycerin as the basis (so-called "glycozone"), and solutions in ether ("ozonic ether": "pyrozone"). The ethereal solution is, naturally, highly inflammable.

Solutions of hydrogen dioxide *bleach* powerfully, and are much used for such purpose.

EDWARD CURTIS.
R. J. E. SCOTT.

Hydrolysis.—By hydrolysis is meant the cleavage or decomposition of the molecules of a substance by a reaction with water. The action of dilute acids upon proteins or the influence of enzymes in general upon their substrates are examples of hydrolysis.

F. P. U.

Hydronephrosis.—Hydronephrosis is an abnormal dilatation of the renal pelvis and calices, usually accompanied by more or less atrophy of the secreting structures, and caused by the temporary retention or permanent accumulation of sterile fluid (originally unaltered urine) in the renal pelvis, due to obstruction at or below the ureteropelvic junction. The amount of dilatation varies within wide limits—from a few cubic centimeters to thirty liters or more, as in the case reported by Mosny, Javal, and Dumont.[1]

ETIOLOGY.—Hydronephrosis may be congenital or acquired; unilateral or bilateral; complete or incomplete; temporary or permanent. It may be primary, from obstructions originating within the urinary tract, or secondary to disturbances elsewhere at any point and of any nature that may cause obstruction to the normal outflow of urine.

Congenital hydronephrosis may be unilateral or bilateral. It is often bilateral, since when ureteral abnormalities are present they often occur coincidently in the two ureters, and it is always bilateral when the obstruction is at the neck of the bladder, or is due to congenital stricture or atresia of the urethra, or to phimosis with very small orifice. Most congenital hydronephroses are due to one or more of the following conditions affecting the ureter: It may be impervious; there may be persistent valves, congenital strictures, a narrowed or occluded vesical orifice; it may take an abnormal course in the bladder wall or empty at an unusual position; there may be an abnormal implantation into the pelvis of the kidney; there may be bends, kinks, or torsion of the ureter due to congenital displacements or other abnormalities of the kidney; there may be pressure upon the pelvis of the kidney or the ureter by anomalous renal vessels or by an accessory ureter, these latter probably representing a persistence of the Müllerian or the Wolffian duct, for they usually terminate in the sinus pocularis in the male or the vaginal vault in the female, hence when distended may distort the bladder and cause angulation or pressure upon the healthy ureter. Multiplicity *per se* is not necessarily a cause of hydronephrosis. Absence of the ureter, usually included in the list of etiological factors, cannot cause hydronephrosis, since the pelvis and collecting tubules of the kidney are developed from the ureter, hence if there be no ureter there can be no pelvis of the kidney. Cystic degeneration of the secretory portion of the kidney, which has been developed from the metanephros, may occur, but this condition should not be confounded with hydronephrosis.

Acquired Hydronephrosis.—Among the numerous causes of this form are: Acquired strictures of the ureter, which may be gonorrheal (as emphasized by Tuffier), tuberculous, or traumatic; ureteritis and periureteritis; impacted calculi at the ureteropelvic junction, in the ureter, or urethra; inflammation or ulceration at the ureteral opening into the bladder; kinking of the ureter and valve formation from acquired movable kidney; stones in the bladder; prostatic hypertrophy; urethral stricture; benign or malignant tumors of the bladder, uterus or other structures, pressure from the pregnant or otherwise enlarged or displaced uterus, inflammatory exudates, peritoneal bands or adhesions. In children, as Cumston[2] remarks, uric acid sand, accumulating at either the upper or lower ureteral orifice, has been said to be the most frequent factor. In many cases the etiological factor does not act continuously, or the obstruction is occasionally overcome, hence there may be intermittent emptying of the pelvic cavity—*intermittent hydronephrosis;* although as Gardner[3] has pointed out, since the term hydronephrosis implies degenerative changes in the renal parenchyma together with the formation of fibrous tissue resulting in the permanent impairment of the kidney, it is the filling and emptying that is intermittent and not the hydronephrosis.

PATHOLOGY.—With the accumulation of fluid there is a gradual distention of the pelvis and calices, with flattening of the papillæ and compression of the medulla. If the obstruction is of brief duration and is followed by complete evacuation of the collected fluid the ureteropelvic cavity returns to its former shape and there is no permanent impairment of the kidney structure. If, however, the distention of the cavity gradually increases, the parenchyma becomes more and more thinned, the secreting structures atrophy, fibrous tissue develops in the intertubular spaces and as a replacement fibrosis of the secreting structures, so that ultimately the kidney may be represented by a fibrous sac from which nearly all traces of epithelial tissue has disappeared, while the amount of contained fluid may be enormous. It has been believed that a greater degree of distention occurred when the obstruction was intermittent or partial; but G. D. Scott[4] has shown from experiments on fifty dogs that sudden complete obstruction of the ureter produces hydronephrosis of great degree, and that while intermittent or partial obstruction of the ureter may also result in large hydronephroses, the increase is less rapid and for equal periods of time the amount of distention is less than when the obstruction is complete; and that in either case the size depends principally upon the duration of the obstruction. Opinion is still divided as to the possibility of regeneration of the secreting structures after long compression. It is certainly true that functional activity after removal of obstruction is often much greater than was expected; and Scott seems to have proven that even in long-standing hydronephroses of extreme degree a large part at least of the renal epithelium will regenerate and functionate.

Perirenal, pseudo-, or *subcapsular hydronephrosis*

is a rare condition in which fluid accumulates between the cortex and fibrous capsule of the kidney, or between the fibrous and fatty capsules. These are usually traumatic in origin, engrafted upon a pre-existing intrarenal hydronephrosis, and almost invariably communication with the pelvis can be demonstrated. The pathology of this lesion has recently been well described and two remarkable cases reported by Buerger.[5]

Symptoms and Diagnosis.—In the early stages of hydronephrosis the symptoms are usually very indefinite and are frequently mistaken for those of other lesions in the upper abdomen, particularly stone, tuberculosis or other infections of the kidney, or for gallstones. J. W. Thomson Walker[6] finds that there are two well-defined clinical groups of cases. In one group some recognized cause of hydronephrosis, such as calculus or movable kidney, is discovered on clinical examination; in the second group no condition which might cause hydronephrosis is found clinically, the obstruction in the latter group usually being due to congenital stenosis or valves of the ureteropelvic junction or to the pressure of aberrant renal vessels. This latter etiological factor assumes greatly increased importance in view of the researches of Rupert[7] who found that seventy per cent. of fifty cadavers examined showed a unilateral or a bilateral anomaly of the renal arteries or veins or both. As a rule, the location and character of the pain suggest a kidney origin. Thus, H. Cabot[8] distinguishes three groups of cases: those suggesting stone in the kidney; cases with symptoms of stone in the kidney but without abnormality of the urine; cases simulating acute infections of the kidney but with a persistent sterile urine. In all of these types there will be pain, usually intermittent, but sometimes occurring as a persistent dull ache. The early attacks of pain are often acute and may be accompanied by nausea; while occasionally the pain reaches the severity of typical attacks of renal colic. As the hydronephrosis progresses the pelvis seems to become less sensitive, the attacks of pain often become less severe and less frequent, and may finally cease altogether. When it is known that there is a stone in the pelvis of the kidney and the attacks of renal colic decrease in frequency and severity a dilating ureter and pelvis are to be suspected. Another early symptom is persistent polyuria in the absence of evidence of nephritis, due to reflex stimulation of urinary secretion. This is not to be confounded with the intermittent discharge of accumulated quantities of urine such as often occurs after considerable distention of the pelvis has taken place. There is nothing characteristic about any of the symptoms of beginning hydronephrosis and an early diagnosis will not be made unless the clinical history, urinary and *x*-ray findings, cystoscopic and general physical examinations lead to catheterization of the ureters, estimation of the capacity of the renal pelvis and, above all, radiography while the ureteropelvic cavity is filled with an opaque fluid (pyelography), thus showing the size and contour of the renal pelvis and ureter, together with their reciprocal relations. This procedure, devised by Voelcker and Lichtenberg in 1905 and popularized by Braasch[9] is, as Cabot has truly said, the mainstay of diagnosis. The essential features in diagnosis by this method are to determine that there is an obstruction, that other possible causes of the symptoms can be excluded, and that distention of the pelvis by injecting through the ureter-catheter produces pain of the same character as previously experienced. Slight increase in capacity may or may not be demonstrated, since irritation may cause spasmodic contraction of the ureteropelvic cavity. After the kidney has become considerably increased in size there should be little if any difficulty in making the diagnosis, particularly if there have been intermittent discharges of large quantities of urine. The history, including the location and character of previous pain, the *x*-ray findings, together with the presence of a palpable tumor occupying the kidney region while the urine is normal, make the diagnosis of the average case easy. In the earlier stages the kidney may be very tender to touch; but in the chronic cases there is little or no tenderness, while with the large hydronephrotic sacs fluctuation can be easily made out. Extremely large hydronephroses have been mistaken for ascites or ovarian cysts; while in young children it may be difficult to differentiate from sarcoma of the kidney or retroperitoneal lymph glands. Aspiration, formerly occasionally practised in these differentiations, is a dangerous proceeding. Hydronephrosis must also be differentiated from congenital cystic kidneys and, rarely, from echinococcus cysts of the kidney, liver, or spleen.

Treatment.—Primary congenital hydronephrosis, if complete and affecting both kidneys, is necessarily fatal except in those rare instances where the obstruction can be relieved practically at once. In all cases the primary indication is to remove the cause of the obstruction if possible. If due to movable kidney, this should be anchored. Strictures of the ureter may sometimes be dilated, otherwise resection and anastomosis or some form of plastic operation may be required. Pelvic, ureteral, or urethral calculi should be removed, and the same is true of obstructions caused by anomalous vessels or an accessory ureter. Obstructions from urethral stricture, prostatic hypertrophy, tumors, or pressure from gynecological sources should receive attention. If upon exposing the kidney a valve at the ureteropelvic junction is found to be the cause of obstruction, Fenger's method of vertical incision and transverse suture may suffice; while there are numerous plastic operations upon the pelvis and upper ureter which may be employed in suitable cases. These remarks apply especially to the early and moderate-sized hydronephroses. In those of long standing and of marked degree the treatment of the kidney itself demands consideration. If it seems probable that any considerable amount of parenchyma will functionate I believe that nephrotomy with temporary drainage is the operation of choice; but when nothing apparently remains but a huge fibrous sac, nephrotomy entails the dangers of infection and persistent fistula while there is little likelihood of sufficient restoration of secretory activity to be of any importance. In these cases, therefore, primary nephrectomy, usually by the lumbar route, is indicated. Before nephrectomy in this as in other conditions the operator will, of course, satisfy himself as to the presence and adequate secretory activity of the other kidney.

Wesley Grove Vincent.

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Hydropericardium.—By hydropericardium, or *dropsy of the pericardium*, is meant a non-inflammatory collection of fluid in the pericardial sac. It is distinctly a transudate and not an exudate. Some authorities include all collections of fluid in the pericardium, inflammatory and non-inflammatory, under this one term. By general consent, however, hydropericardium and hydrothorax are understood to mean

transudates. A few cubic centimeters of fluid are practically always found in the pericardium at autopsy and Rosenbach calls even this quantity a hydropericardium, since he considers it as an agonal transudation. It has been observed that this quantity varies with the length of the period between the death and the autopsy—the longer the wait, the larger the amount of fluid—which suggests that most of this fluid is due to postmortem transudation. Practically the condition is first spoken of as hydrops pericardii when the amount of fluid reaches 100 c.c.

Like transudates in other parts of the body, this fluid is light yellow or slightly greenish yellow, usually clear, though it may contain blood. It is alkaline, with a specific gravity usually below 1,018 and contains only solitary cells and a few flakes of fibrin. It usually contains a certain amount of urea and may contain bile, sugar may be present. There are no observations on the depression of its freezing point. The percentage of albumin, according to Reuss, is less than in pleural transudates, and greater than in peritoneal transudates but always less than that in any of the exudates. The quantity of fluid varies very much, depending on many circumstances. It may reach from 500 to 750 c.c. Corvisart has reported the enormous quantity of eight pounds—about 4,000 c.c.

The pericardial sac is distended according to the amount of fluid: in the large collections the lungs are compressed and the diaphragm is forced downward. The serous surfaces of the pericardium are smooth and glistening, usually pale because of the compression of the vessels though in some instances the veins may be distended. The subserous tissue is usually edematous. After the long duration of such a fluid collection, the subserous fat disappears and the endothelial cells are relaxed, swollen and of granular opacity. The pericardium proper is thinned, or if the case is of long standing or slow development, it may be thickened. The myocardium is pale and flabby but not otherwise changed.

Scientific opinion is as yet divided in the explanation of the presence of transudates. By many transudation is considered a process of filtration; others hold that the capillary walls are to be regarded as living organs, with a capacity for secretion, under the stimulating influence of irritating substances in the blood.

Etiology.—Hydropericardium is never a primary disease, being either a part of a general dropsy or the result of local circulatory disturbances. Because of the incessant activity of the heart it is much less frequent than similar collections of fluid in the pleural and peritoneal cavities. Its etiology is that of hydrops in general—disease of the circulation, respiration, blood, and kidneys. It occurs occasionally as a very rapid collection of fluid in some cases of acute nephritis, as in scarlatinal nephritis. Most commonly it is a part of a chronic dropsy associated with diseases of the heart and kidneys. All disease processes which develop hydropericardium can be divided into two classes: those in which the condition of the blood is so changed that the vessel wall becomes altered and permeable—cachexia following tuberculosis, cancer, malaria, syphilis, severe anemia, heart, lung, or kidney disease; or by an exudation from the veins of the pericardium, the coronary veins, or the lymph channels of the heart, occurring in dilatation of the right auricle, disease of the respiratory apparatus, emphysema, myocarditis, valvular disease of the heart, atherosis of the coronary arteries, aneurysm, and tumors and inflammations of the mediastinum. Very rarely the dropsy has a predilection for the pericardial sac, rather than for its usual locations. In rare cases the sudden development of a pneumothorax is followed by hydropericardium.

Symptoms.—These are rather indefinite and can scarcely be separated from those of the associated disease. Dyspnea and cardiac distress rarely may be chiefly dependent upon the hydropericardium. Pain and fever are almost uniformly absent since the condition is not an inflammatory one.

The physical signs are those of pericarditis with effusion except that friction sounds are not present. The area of dullness is said to be not quite so triangular in shape, the angles being drawn out more into points. The lack of adhesions in the non-inflammatory processes allows a greater mobility of the fluid and as a result of this the flatness is not quite so absolute and may change its borders on change in the position of the patient. As a rule there is not a coincident myocarditis so that the apical impulse may be comparatively strong.

Diagnosis.—The condition comes on insidiously and often would not be recognized were it not for careful physical examination. If, however, it develops while the patient is under observation its diagnosis is not usually difficult. The presence of dropsy in other parts of the body and the change in the physical signs being enough to determine the diagnosis. In case of doubt an *x*-ray examination would probably help. Pericarditis with effusion is generally accompanied by pain and fever and a pericardial friction rub may be heard. An exudate rarely presents free mobility of the fluid or a horizontal upper level of dullness while they are not infrequent with a transudate. Rosenbach states that if potassium iodide be given by mouth or injection it will be excreted into transudates but not into exudates. A marked hypertrophy of the heart causes the greatest difficulty in diagnosis. The strength of the apex beat and the fact that with cardiac hypertrophy the dullness rarely reaches the second rib are generally sufficient to differentiate them. The administration of digitalis usually effects a rapid reduction of a large area of dullness due to cardiac dilatation.

Prognosis.—The prognosis is always grave, as the condition occurs in an advanced stage of the fundamental disease. The fluid in the pericardium adds an extra impediment to the already weak heart and thus hastens the fatal issue. In rare cases, as in the effusions associated with acute nephritis, there may be recovery.

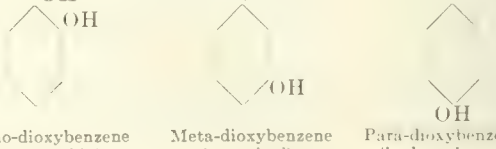
Treatment.—The treatment is essentially that of the primary disease with cardiac tonics and diuretics. Usually paracentesis only delays the fatal issue a short time. However in rare cases it may be distinctly useful, that is when the patient seems to be dying as a result of great local obstruction in the pericardium, which is overwhelming the heart. In certain instances diuretics do not work well until the fluid is removed from the pericardium. The operation is not difficult, but must never be undertaken unless the diagnosis be certain. For a description of the operation see the article on *Pericarditis*.

James Rae Arneill.
Revised by Ralph G. Stillman.

Hydrophobia.—See *Rabies*.

Hydropneumothorax.—See *Pneumothorax*.

Hydroquinone.—Hydroquinone, or *quinol*, or *hydrochinon*, as it is called by German authors, is chemically *paradioxy-benzene*, $C_6H_4(OH)_2$, one of a trio of isomeric diatomic phenols, of which resorcinol and pyrocatechin are the other two members.



Ortho-dioxybenzene (pyrocatechin) | Meta-dioxybenzene (resorcinol) | Para-dioxybenzene (hydroquinone)

Hydroquinone appears in transparent, colorless, rhombic plates or prisms, fusible at 169° C. (336.2° F.,) and subliming without decomposition. The crystals dissolve readily in alcohol, ether, and hot water, but in not less than seventeen parts of cold water. The reaction is neutral and the taste slightly bitter.

Hydroquinone has been proposed as an antipyretic. It is capable of producing convulsions and other derangements in the lower animals, but in therapeutic doses, in man, operates as a speedy, but transient, antipyretic in fever. In such operation the medicine is well borne, even so large a dose as forty grains producing no derangement worse than a very transient feeling of fulness in the head and slight giddiness, and ordinary doses being free from even this effect. The fall of temperature begins, as a rule, within half an hour after administration of a single dose, reaches its maximum in from two to two and a half hours, and the ensuing rise attains the original temperature in from one to two hours additional. For a transient impression such as described, a dose of from 1.00 to 1.33 gm. (from fifteen to twenty grains) suffices, while for a continuous one, three or four such doses should be given during the twenty-four hours. During continuous medication with hydroquinone the urine may appear of a dark-brown color, due to the presence of products of decomposition of the medicine.

EDWARD CURTIS.
R. J. E. SCOTT.

Hydrorrhachis.—See *Spina Bifida.*

Hydrosol.—Certain colloids solidify in a gelatinous form containing a relatively large quantity of water. In the case where water is the solvent the soluble form was called hydrosol and the gelatinous form hydrogel. F. P. U.

Hydrotæa.—*H. meteorica* is a fly which attacks animals' eyes and nostrils. It is said to affect man sometimes. See *Insects, parasitic.* A.S.P.

Hydrotherapy.—In the present enlightened era of medicine the chief aim of the physician is to aid the inherent powers of the human organism to eliminate morbific agents and reinstate the disturbed equilibrium of the economy, by all means which enhance the patient's capacity to resist the inroads of disease. In the accomplishment of the latter water plays an important part. The simplicity of this remedial agent and the neglect of precision in its application have been the chief obstacles in the way of its more universal acceptance. The fact that water is one of the few remedies which has survived since the day of Hippocrates and has been advocated and used by the most eminent physicians of every time, was the writer's incentive to its investigation thirty-five years ago. The clinical results obtained by him have won his highest esteem, especially since he discovered that its action is based upon recognized physiological principles. The latter must be clearly understood before the real value of hydrotherapy can be appreciated.

The action of water upon the human organism is derived from its physical and mechanical effects.

The physical qualities of water are utilized in hydrotherapy because it is an excellent vehicle for conveying the thermic and mechanical effects aimed at. Water absorbs and gives up heat readily; it may be used in solid liquid, or gaseous form, it may be applied to any limited part of the body or to its entire surface. Hence its physical property alone makes it a most flexible therapeutic agent.

Thermic agents affect living tissues in the most pronounced manner. Smooth muscular fiber contracts under cold and expands under heat, and its contractility may be entirely destroyed by an excess of either. By the conveyance of cold or heat by means of water we are, therefore, enabled to produce striking effects upon vital processes which depend upon muscular activity. As cold and heat are irritants, their reflex effects conveyed through the nervous system also become valuable therapeutically. Applying these axiomatic principles, we find that circulation, respiration, tissue change, and heat production may be positively influenced by the application of water as a medium of conveyance of cold and heat, and that abnormal conditions of the functions may be remedied and their healthy equilibrium restored. That such effects are really produced, laboratory experiment as well as observation at the bedside has again and again demonstrated.

In my book on hydrotherapy* many experiments are detailed showing the influence of hydriatic procedures upon the caliber of blood-vessels, the action of the heart, and even upon the composition of the blood, the respiration, and the secretions. All applications of cold involving the entire surface of the body, or a considerable part thereof, result in an increase of the number of blood cells; the percentage of hemoglobin and the specific gravity of the blood are also increased when reaction, manifested by cutaneous hyperemia, ensues. When reaction fails, the erythrocytes, and often the leucocytes also, are diminished.

That these effects may be utilized to explain the rationale of cold applications in disease has been often demonstrated. For instance, Thayer, of Johns Hopkins University, observed that the blood drawn from the lobe of the ear of a typhoid-fever patient after a Brand bath, contained three times the number of leucocytes, ascertained by actual count to be present previous to the bath. This has been confirmed by Winternitz, Breitenbach, myself, and others, in chronic cases and in healthy persons. Since this enormous increase could not be the result of new production during the fifteen-minute bath, the conclusion is inevitable that the increased activity of the circulation, induced by the changing anemia and hyperemia of the cutaneous surface resulting from the cold bath and friction, has driven these cells from their hiding-places on the outskirts of the blood stream and elsewhere, and has brought them into active service.

Cold improves the muscular tone of the vessels, *i.e.* it increases tension; warmth relaxes, causing passive dilatation and loss of tone. Although both produce a hyperemia, one is the result of reaction and is tonic, while the other is the result of relaxation and is atonic. This trite fact is sadly disregarded in practice. Its more general recognition will do much to neutralize and remove the fear of shock from cold applications in atonic conditions.

The reflex effect of cold and heat conveyed from the skin to the central and sympathetic system, thence to organs and tissues, is an important therapeutic factor, and demonstrates that the thermic action of water upon the human organism is capable of influencing its every part and function in the most pronounced manner.

By guiding and directing these well-ascertained effects of cold and heat, as conveyed by water to the skin, we may evoke changes in the circulation, remove stasis in one and fill another vascular area, deplete others, and thus aid powerfully in removing pathological states.

Water may be applied with accurate dosage by varying the temperature, duration, and pressure. A very high or a very low temperature produces destruction of tissue, while cold and moderately hot water produce a rubefacient effect. Water driven under high pressure destroys tissues, and under moderate

* "The Principles and Practice of Hydrotherapy," William Wood & Co.

pressure causes rubefacient or stimulating effects. For this reason accurate prescriptions of temperature, duration, and technique are demanded. The conventional ordering of a "cold sponge," a "hot bath," etc., is so indefinite that it invites failure.

There are also various modifications in hydriatic technique which must be clearly understood before we employ hydrotherapy in disease.

Technique.—It is the aim of this article to simplify hydrotherapy and render it accessible to the general practitioner. Minute attention to details is the first essential for the successful application of all hydriatic procedures; without this, failure is sure to ensue. The following procedures are best adapted for the application of water in disease: Ablution, affusion, sheet bath, drip sheet, compresses, wet pack, tub bath, douche. Their application in various diseases will be shown.

Ablution consists of the application of water by the hand, or with a wash cloth, over successive parts of the body. The method and the temperature of the water vary with the object in view. In febrile conditions the chest, the back, the abdomen, and the lower extremities as far down as the knees are successively bathed every two or three hours, beginning at 75° and reducing the temperature by one degree at each application until 60° F. is reached. It is important to avoid chilling and to bear in mind that reaction is aimed at.

In chronic affections the ablution is a useful preliminary to the more active hydriatic procedure. The patient is first warmed by being snugly wrapped nude, in two long-haired woollen blankets, like a mummy, for one hour. The face is bathed in water of 60° F.; the blankets are successively opened over his chest, abdomen, back, lower extremities to the knees, and these are bathed with the hand, each part being immediately dried and replaced under cover. A general dry rubbing with a woollen cloth, or the hand, follows.

For the General Ablution the patient stands in twelve inches of water at 95° to 100° F., and is rapidly washed down with the hands, while water—of a temperature of 80° F. at first, but on each succeeding day of a little lower temperature until 60° F. is reached—is poured upon him with the hand or from a vessel. Afterward he should be subjected to gentle friction. Reaction must always be produced.

The *rationale* of the action of ablutions may be found in the gentle shock and reactive stimulus, which is refreshing. The superficial capillaries are dilated, as evidenced by the rosy hue of the skin following ablution with friction, the inspiration is deepened, and cardiac action is bettered.

Affusion.—Having a wet cloth around the head, the patient, sitting or standing in a tub containing twelve inches of water at 100° F., receives a broad stream of water poured with force from a basin, bucket, or pitcher. According to the height from which the water is poured and the lowness of the temperature will be the stimulating effect. The affusion is useful in coma and in stuporous delirium, indicating adynamia and nerve prostration. By this method Currie made his remarkable cures in typhus fever, using chiefly sea water, the patients lying on the deck. In *scarlatina*, when the system is overwhelmed by the poison, the circulation embarrassed, the skin pale or marbled or cyanotic, the respiration shallow, temperature high, pulse rapid and feeble, truly marvellous results may be obtained by the judicious use of brief affusions. Reaction occurs rapidly, and with it come an improved peripheral and general circulation, deepened inspiration, bright countenance, and roseate skin. Rapid affusions of water at a temperature of from 70° to 60° F., have, in my experience, saved lives in these desperate cases.

Sheet Bath.—A rubber sheet covered by a blanket is laid upon one-half of the bed. A linen sheet is now dipped into water having a temperature of from 60° to 70° F., according to the effect desired, and, *without being wrung out*, is laid upon the blanket; the patient, whose face has been bathed with ice-water, and upon whose head a wet cloth is placed, is moved over to the wet sheet, which is wrapped snugly around him. The first impression will be a surprise—called shock—to the cutaneous nerves. Reaction ensues from the patient's own temperature, and its establishment is aided by the manipulations of the nurse, who, with out-stretched hands, gently but firmly sweeps over the wet sheet, omitting the legs and forearms. So soon as one part of the body becomes thoroughly warmed, water from 50° to 60° is poured from a cup or squeezed from a sponge over it, until it again cools. These passes, or frictions, are alternated with the pouring on of small quantities of cold water, until the entire body feels cooled or the patient shivers. Rigor must always be avoided, because it is an evidence of contraction of the vessels. As the friction prevents this objectionable feature of all cold baths we have in the sheet bath an admirable roborant antipyretic, the effect of which may be greatly enhanced by allowing the patient to remain in it, after wrapping him in the blanket, for half an hour. Its mildness as compared with the full cold baths, for which it is an excellent substitute, renders it more acceptable to the patient and his friends, and it may thus be utilized as a valuable initiatory antipyretic measure. It is applicable in all acute diseases in which an elevated temperature is a leading manifestation.

Drip Sheet (Fig. 3301).—In chronic cases the sheet bath is a useful adjunct, and in many cases an important element of the treatment—as, for example, in phthisis, in neurasthenia, and in chlorosis. Here it is called a drip sheet, and is applied while the patient stands in water of 100° F.

The flexibility and simplicity of the method commend it especially. By wringing the sheet out well (cold rub), or by using a coarser sheet, or a lower temperature, for a short time, or by slapping with the sheet, instead of simply rubbing the hand over it, the local excitation of the cutaneous nerves and vessels may be enhanced. By saturating it with more water, the antipyretic effect is increased, and this may be still more intensified by more prolonged application.

The compress is made by cutting four folds of old linen to fit the part. The cloth is more or less wrung out of water at or a little above 60° F. and secured by a flannel bandage wider than the cloth. For tonsillitis it is very useful if applied, not around the neck but from ear to ear and secured by a flannel bandage pinned on top of the head. For articular rheumatism a compress snugly secured by a thin flannel bandage of one layer hastens recovery. In pneumonia the compress, surrounding the thorax like a vest and secured over the shoulder and around the chest by pins, is of paramount value. The abdominal compress is useful in all fevers, as is the trunk compress, enveloping the entire trunk. Compresses are usually renewed every hour in acute cases, and always covered by one layer of flannel to permit evaporation—never covered by oiled silk, which would convert them into a poultice.

The Ice Bag may here be referred to. This should always be covered with flannel and never allowed to remain continuously for a longer time than forty-five minutes. It should be replaced at the end of fifteen minutes. Its utility in internal hemorrhages is fallacious, because the blood is driven from the surface into the collateral circulation beneath. Its beneficial effect as an antipyretic for parts situated deeply is fallacious, as proved by the experiments of W. Gilman Thompson and others. The same remark holds true for the ice coil. As an application in feeble and irregular heart action the ice bag is invaluable, if reaction is permitted. The ice coil is

a fallacious procedure in fevers, because it cools only the parts beneath it, making them cyanotic, and therefore retards the circulation.

Fig. 3301.—Drip Sheet Mode Friction.

Wet Pack.—A large woollen blanket is spread upon a mattress. Upon this is spread smoothly a linen sheet, *wrung out* of water of a temperature of from 50° to 70° F., according to the nature of the case; the blanket should be long enough to extend from the nucha to a foot or more beyond the patient's extremities. The patient, with a wet cap upon his head, places himself upon the sheet, with his arms raised above the body. One-half of the sheet is now rapidly folded around his body and pressed between the arms. The arms are lowered into position alongside of the body and the other half of the sheet is drawn over the body. It is snugly secured around the neck and beyond the feet. The blanket is now drawn firmly from the left and tucked under the right side of the body, the right border of the blanket being drawn over to the left in the same manner; then, finally, it should be secured firmly under the body and around the neck, and should be folded over the feet (Fig. 3303). *Success depends upon exclusion of the air by the blanket cover.* If the latter has been skilfully applied, the patient will resemble a mummy, and will get warm in an hour or less.

The wet pack must be followed by some hydriatric method which restores tone to the cutaneous vessels which have been relaxed by it. A sheet bath or a cold affusion will serve this purpose, or an alcohol rub, if given for insomnia.

The cold sheet produces irritation of the cutaneous nerves, and contraction of the peripheral vessels, and the latter state persists until reaction ensues. Inasmuch as no mechanical aid is given by the attendants, the reaction must depend entirely upon the vital powers of the patient. As soon as the first shock is over—which lasts from five to twenty minutes, and sometimes produces shivering—the cutaneous vessels begin to dilate, and the temperatures of the skin and of the sheet approach equality. This equalization of the two temperatures occurs quickly in fever patients, and slowly in persons having a normal temperature. The sheet bath is, therefore, superior to the wet pack as an antithermic procedure. Many failures are due to the use of the wet pack in fever; it is far more useful in chronic cases.

In chronic diseases the patient is wrapped in a sheet wrung out of water at from 60° to 70° F. as indicated; the higher temperature being employed at first and this being gradually reduced by one or two degrees at each succeeding treatment. Lying for an hour in this pack the patient's body is enveloped in a vapor of its own creation. The reactive labor thus involved is a great benefit to the circulation, and it has been demonstrated to aid in enhancing tissue metamorphosis. The patient often falls asleep. The calming effect of an hour's sleep in the wet pack is valuable in functional neuroses, hysteria, and some heart troubles. It is superior to the hot pack in insomnia and excited mental states.

The therapeutic application of the wet pack is extensive, the procedure being valuable in all chronic cases in which defective tissue metamorphosis is a prominent element, as in *diabetes, rheumatism, gout, anemia, chlorosis,* and some disorders of the digestive apparatus.

Fig. 3302.—Application of Chest Compress.

The Full Bath.—A tin tub six feet long, and filled to three-fourths of its depth with water at a temperature of from 80° to 65° F., is placed near the patient's bed in acute cases and shut out from view by a screen. A double blanket covered by a linen sheet is spread upon the side of the bed to be occupied by the patient after the bath, the pillow being covered by a towel. The patient now receives a cup of hot black coffee. He is undressed and a light napkin is applied over the sexual organs. His face is bathed with ice-water, and, if too feeble to step into the bath, he is lifted into it by two assistants, preferably on a small hammock, from which the sticks have been removed. With the greatest gentleness and least fuss he is lowered into the water. He gasps and shudders a moment, or perhaps cries out. But gentle reassurance by word and deed, a calm demeanor, devoid of haste, and the absence of all actual force or argument will quiet him. Friends or relatives must be kept out of the room. An air cushion suspended at the head of the tub will make a head rest, and a large water cushion ring makes a comfortable support for his nates. Two nurses must constantly practise good friction or chafing over *successive* parts of the body. These frictions are of *supreme importance* in preventing chilling, collapse, cyanosis, and heart failure. The effect of the continuous gentle chafing is a suffused redness, which demonstrates that the caliber of the cutaneous vessels is considerably enlarged. As this is being done in successive parts of the body, we really manage to maintain a constant contraction and dilatation of the peripheral vessels, the former being accomplished by the contact with the cold water in motion, the latter by the friction and its attendant reaction. Complaints of chilliness must not be regarded as an indication for removal of the patient from the bath, unless they be accompanied by decided chattering of the teeth, or the face becomes cyanotic. Several times during the bath, which usually lasts fifteen minutes, a basin of water at 50° F. is gently poured over the patient's head and shoulders, if the patient is somnolent or delirious. The bath being finished, the patient is gently lifted out, the napkin covering the sexual organs rapidly dropped, and he is placed upon the previously prepared linen sheet, so that the upper edge extends above his shoulders to the nucha. He is now carefully wrapped in the sheet, a fold being pressed in between the arms and the body and between the lower extremities. The blanket is now wrapped around the patient. If the body temperature has been high, above 103° F., in the rectum, the patient is allowed to lie in the sheet for five or ten minutes; if the temperature is lower he should be at once dried with the sheet and afterward with soft towels. In either case hot bottles are to be placed against the feet. Usually the patient will fall asleep.

When a bath having a temperature of from 70° to 65° F. is given every three hours in the case of a patient who has a rectal temperature of 103° F., this may be looked upon as the ideal bath designed by Ernest Brand, of Stettin, for the treatment of typhoid fever.

In the case of the graduated bath, devised by von Ziemssen, the preparation for bathing and drying the patient is the same as in the Brand bath. The tub is filled with water at 90° F. Colder water is added for half an hour until the water temperature reaches 68° F. *Chafing is here also an all-important element of the bath.* The patient is wrapped in a prepared sheet and blanket without being dried for a quarter of an hour, and then he is dried and his clothing replaced.

Fig. 3303.—Wet Pack, Showing Method of Tightening Blanket Around Neck.

The rationale of the cold baths, which have been chiefly applied in typhoid and other infectious fevers, is so exact and scientific that it must lend firmness born of conviction to the attendant who applies them with a clear understanding of their aims and capabilities. The nervous system is overwhelmed by toxemia. An indefinable malaise is followed by ataxia, general lassitude, somnolence, and other adynamic manifestations, which culminate in severe cases in stupor, delirium and coma, subsultus, tremor, etc. The heart, being called upon to do extra duty, threatens to fail, and often does fail, not owing to the elevated temperature only, but to a paretic condition of the capillary circulation, induced by the infective process, which embarrasses the propulsive action of the cutaneous arterioles.

The depreciated condition of the nerve centers, which in typhoid and similar fevers is the leading point of attack, must be the leading point of defence. From it originates a condition of the circulation which, by its effect upon the peripheral vessels, not only disturbs heat radiation, and thus develops temperature elevation, tympanites, etc., but later gives rise to other most perilous conditions, such as failure of the heart, local hypostases, bed-sores, etc. The stimulating, refreshing effect of cold water and friction upon the terminal fibrillæ of the sensory cutaneous nerves is conveyed to the central nervous system; the gasp emitted by the patient is evidence of a reflex effect. The cutaneous arterioles are stimulated and dilated in reaction, filling with cooled blood, and thus the heart, laboring ineffectively to overcome these paretic conditions, is afforded some relief. Elastic resistance at the periphery is increased by the contraction of the abundant non-striated muscular structures of the skin, by which the blood is pressed out of the capillaries and which yield slowly under the increased inflow of

warm arterial blood arising from the thermic vasomotor stimulation. The ventricular contraction becomes more complete, and the blood courses with increased vigor through the entire organism. Excretion is enhanced, and the vitality of the patient rises. The patient's condition is the best evidence that these effects are salutary. He who has witnessed the dull eye of a typhoid patient glisten after a cold friction bath, who has felt the dicrotic pulse rebound, who has seen the apathetic countenance brighten, the urine increase, and slumber ensue, must be convinced of the value of cold procedures in infectious fevers. Reaction must always be induced by friction during the bath.

In Typhoid Fever, the Brand bath, above described, is of the greatest value, as clearly shown by the only absolutely reliable medical statistics extant. Dr. Vogl, medical director of the Bavarian army, has published the records of a period of forty years, covering all types of epidemics of typhoid fever and all kinds of treatment; and according to these statistics, based upon 8,500 cases of the disease occurring in soldiers, the mortality has been reduced by the Brand bath from twenty-two per cent. down to three per cent. The subjects being all of the same sex, occupation, age, and environment, and the inquiry covering large numbers and a long period, these statistics are unique and absolutely reliable. In civil hospitals, Gilman Thompson, William H. Thomson, Tyson, Hare, and Brisbane, 1,900 cases collated by the author, mortality was reduced to 6.22 per cent. Statistics of 125,333 cases in various countries under expectant treatment show a mortality of 20.76 per cent.; the Brand bath in 7,426 cases shows a mortality of 4.26 per cent. The reason for greater success in military practice is found in the earlier application, because the cold bath *prevents* lethal complications.

The writer's method of procedure is as follows: When he suspects that he is dealing with a case of typhoid fever he proceeds at once to use ablutions every two or three hours, applies an abdominal compress between the ablutions, and then orders a sheet bath of from 80° to 70° F.

Diagnostic Bath.—On the second day he orders the diagnostic bath if the rectal temperature reaches 102.5. This consists of a friction bath at 90° for fifteen minutes, as above described, to be succeeded every four hours by others at 85°, 80°, 75°. These may be taken in the bath-room to which the patient may be slid upon a rocking chair. If one of these baths reduces the rectal temperature two degrees or over, typhoid fever may be positively excluded (during the first week only). When the diagnosis becomes positive the baths must be administered in a six-foot tin tub, placed alongside of the bed, eighteen inches from the floor. The temperature of the bath should never be less than 65° F., but cold enough to produce good reaction—70° to 75° F. being the average. Active friction must be continued for fifteen minutes, and affusions given as above described. This is the Brand bath given every four hours as long as the rectal temperature registers 103° F. Its repetition must be guided by the reaction and absence of lasting chilliness. If reaction is imperfect, the bath should be abbreviated, *not abandoned*. Abdominal compresses at 60° F. are always applied between the baths.

Fig. 3304.—Baruch's Douche Room.

When this bath cannot for any reason be obtained, the *sheet bath* is an excellent substitute, because it furnishes the thermic excitation and the reaction is furthered by friction over the sheet. A *towel bath* is also useful when the sheet bath is positively inapplicable. This consists of a towel smoothed, dripping, over the back and successively over the glutei and the front of the body, and friction with a block of ice held in gauze, until each part is cooled. The patient is dried and left to rest. This may be repeated every two or three hours. All cold baths must be given with friction, and chattering of the teeth and cyanosis must be avoided.

In Scarlet Fever and Measles the tub bath of 90° F. gradually reduced to 85° F. without friction, continued for from eight to twelve minutes, and repeated every four hours, is soothing and antithermic.

Pneumonia.—Happily, the day of fighting pneumonia as a disease is passing away. The enlightened practitioner prepares the pneumonia patient by providing him with a comfortable bed, pure air, easily assimilated food and drink, and good nursing. He no longer relies upon aconite, veratrum, quinine, repeated antipyretics, morphine, stimulants, and stuffing, because he recognizes these to be impedimenta, when the patient should be stripped for the fight. They embarrass the eliminating function, impair the appetite, and cripple his resources. The application of cold water, on the contrary, meets all the indications for which these powerful remedies were formerly applied—and it accomplishes it without their depreciating effects. What affords more comfort to a child suffering from pneumonia than a tub bath with good friction in water of 95°, reduced during five to eight minutes to 85° or 80° F.? A few baths of this kind repeated every four to six hours, without fuss or confusion, at the bedside (not in a bath-room), calm the respiration, reduce temperature, promote sleep, slow and strengthen the pulse, and refresh the oppressed nervous system. In the interval between the baths I am in the habit, if the temperature and pulse are high, of wrapping around the upper half of the trunk a compress made of three folds of old linen and wrung out of water at 65° F. and always covered by a wider bandage of one layer of thin flannel (without oiled silk), snugly secured over the compress.

By renewing this compress every hour the good effects of the bath are maintained and their frequent repetition is rendered unnecessary.

In the adult patient the tub bath is not so useful, because it involves more trouble to, and disturbance of, the patient, especially if pleurisy be present. Here the wet compress around the chest, not too firmly wrung out of water at 60° F., usually fills all therapeutic indications. It becomes hot, and when removed the reapplication causes a deep inspiration, a betterment of pulse quality, and an increase of urine. The latter is also enhanced by draughts of from four to six ounces of water at 45° F., administered regularly every two hours.

No claim is made that cold water cures the disease. The object of these mild cold procedures is to fortify the patient's resisting powers and thus to aid him in maintaining a successful defence against the disease until its natural limitations are reached. The frequency of application, the temperature of the water, the extent of the saturation of the compress, the duration of the bath, the selection of the procedure, are matters for judgment in each individual case. That we can utilize all these, and thus adapt them to conditions as they arise in each individual case, gives this remedial agent a positive advantage over all others and entitles it to more extensive trial and study than it has received. Large clinical observation is the basis of these views.

The Douche is a procedure by which water is driven upon the patient's body from the nozzle of a hose the internal diameter of which varies from one-eighth to one-half inch. The ordinary shower bath and the needle bath are multiform douches. The water is usually supplied from a reservoir placed at a height of from thirty to seventy feet, and giving a pressure, at the nozzle, of from fifteen to thirty-five pounds to the square inch. A douche table has been devised by the author (1894) by which the temperature, duration, and pressure are regulated before the patient receives the water. This apparatus is useful only in institutions. It has been adopted in the United States (St. Elizabeth) Hospital in Washington and in many other lunatic asylums. It is adapted only to hospitals treating chronic cases in large numbers.

Chronic Diseases.—Chronic diseases furnish such a favorite field for hydrotherapy that no internal disease should be yielded up as hopeless until this mode of treatment has been systematically tried, in connection with all those hygienic agencies which are usually of more avail than medicinal agents, viz., exercise or rest, diet, drink, clothing, climate, etc.

Neuro-vascular Training.—The author has devised the following precedure which even the tyro may use in nearly every case requiring tonic measures—Begin by ablution with a bath glove or wash cloth squeezed out of water at 90°, reduce temperature of water daily two or more degrees until 60° F. are reached, provided the patient reacts well after each procedure, followed by good friction, which is a sine qua non *during* all cold procedures also. Now affusions are begun (see technique) with water at 80°, reducing daily until 60° F. Then the dripsheet as described. These measures afford great latitude in energizing the system, enhancing its vital capacity so as to throw off the materies morbi or reëstablish the equilibrium of the circulation and nerve centers. (See above for technique.)

A case of anemia, for instance, which has resisted iron, strychnine, malt, digestives, etc., often assumes a different aspect when the neurovascular discipline produced by this treatment is secured. The effect of increased oxygenation may be greatly aided by following daily treatment with exercise in the open air. The pallid lips assume a ruddier hue, the languid eye brightens, the step becomes lighter. Appetite and assimilation are improved because of the enhanced hematosis and improved circulatory conditions in the gastrointestinal mucous lining. (For rationale see above.)

Neurasthenia.—A type of cases which I see quite often is that trying class of neurasthenics who wander from one doctor's office to another, and sooner or later become the prey of charlatans. These patients present every phase of depreciated vascular and nerve condition; some are the prey of morbid fears and become the despair of family, friends, and physician. If such a case be subjected to a methodical course of hydrotherapy the result will often prove a revelation, provided there be no organic basis for the malady. If mild procedures do not meet the indications, douches adapted with regard to temperature, duration, and pressure to each individual case, play the most important rôle here. These are capable of arousing the dormant neurons, enhancing vascular activity, and improving general and local nutrition. The cortical centers, which are the chief points of failure in these depressed neurasthenics, feel the impulse of a better circulation and nutrition. The morbid ideas and illusions vanish. The hypochondriacal introspection ceases, and the patient slowly but surely regains his neurovascular equilibrium. The results of hydrotherapy in such cases are, in my experience, far more enduring than those following other methods of treatment.

Insomnia is markedly affected by hydriatric measures as is amply demonstrated in the Vanderbilt

clinic. Neurovascular training during the day with the properly applied wet pack is a sovereign remedy. The pack must be used at bedtime. The patient may remain in it after he sleeps, never longer than an hour if he does not sleep.

Rheumatism, Sciatica, Gout, Neuritis.—Another set of cases which are greatly benefited by hydrotherapy are those unsatisfactory rheumatic, gouty, and lithemic conditions which are the bane of the doctor's life and which we are often so glad to rid ourselves of by sending them to the hot springs. These may be very satisfactorily treated at home. The hot bath pack is the most useful procedure. Patient is laid into a tub of water at 101°, which is rapidly raised to 106°. A hot sheet must be previously provided, wrapped in flannel, also two blankets spread upon the bed. The duration of the bath is six to ten minutes. On arising the patient is enveloped in the hot sheet, slips his feet into hot slippers, lies without removing sheet, on the blankets. The latter are snugly wrapped around him. He receives one to two ounces very cold water, lies in pack one hour, then is dried rapidly and rubbed with alcohol. This bath may be repeated twice or three times a week, alternating with mild tonic procedures.

My personal experience with hydrotherapy in chronic diseases extends over a period of twenty-five years and embraces a very large number of cases of the most varied pathological conditions. The application of this method of treatment to such varied diseased conditions is rendered possible by its flexible nature, which enables the physician to adapt it, by modifications of temperature, pressure and duration, and numerous technical details, to the most varied pathological manifestations, provided he has mastered the rationale of its mode of action, and provided the carrying out of the details is not left entirely to the judgment of bath-nurses. It would be much better to consult some work on hydrotherapy than trust the latter.

When douches are needed, only institutions under the supervision and direction of a trained physician should be resorted to, for in no other way shall we be likely to avoid the dangers of the empirical application of the procedure, which has so often brought disaster to both and discredit to this remedial agent.

SIMON BARUCH.

Hydrothorax.—*Dropsy of the Pleura.* "Hydrothorax is a transudation of simple non-inflammatory fluid into the pleural cavities." It always occurs as a process secondary to other conditions. The quantity of fluid varies but is less, as a rule, than that found in pleurisy with effusion. The fluid is clear and yellow, though it may be more or less blood-tinged, and is free from flakes of fibrin. It is alkaline to litmus and has a specific gravity usually of less than 1,015. It shows little tendency to spontaneous coagulation and compared with the fluid of an exudate it contains but little albumin and few cellular elements. The pleural membrane is usually smooth and glistening though it and the subpleural tissues may be markedly edematous. In the majority of cases hydrothorax is bilateral. Usually, however, there is more fluid in the right pleura than in the left and when the condition is unilateral the right side is more frequently affected. When the cause of the hydrothorax is a cardiac condition it is more liable to be unilateral. Stengel attributes the localization of unilateral transfusions in the right side to pressure on the azygos veins.

ETIOLOGY.—Hydrothorax occurs as a part of a general dropsy, however caused. It is most frequently due to cardiac or renal disease but may be a part of the edema occurring in leukemia, pernicious anemia, carcinoma, malaria, syphilis, or scurvy. Rarely it is due to hindrance to the outflow of venous blood from the thorax as in compression of the vessels by tumors.

SYMPTOMS.—The subjective symptoms are due wholly to the mechanical interference with the respiration and are dyspnea and discomfort. The objective symptoms are practically the same as those of pleurisy with effusion (*q.v.*) though it differs in that there is rarely a friction rub to be heard and the area of dullness is said to change more readily upon change in the position of the patient. Bronchial respiration may be very loud, resulting from the compression which is apt to be more complete than in pleurisy with effusion because of the absence of adhesions and the more normal condition of the lung tissue. There is never fever or pleural pain. The condition usually develops very slowly and is easily overlooked unless frequent careful examinations are made. It may, however, develop very suddenly in cases of scarlatinal nephritis. If it progresses it may prove to be the immediate cause of death in some patients by obstructing the respiration.

TREATMENT.—This is essentially that of the primary causative condition. The hydrothorax itself, unless it be of sufficient size to cause difficulty in respiration, is generally neglected. When dyspnea becomes marked the fluid should be removed by paracentesis. This operation is fully described in the article on pleurisy with effusion. It should be performed with great care and it must be remembered that it is not free from danger. It is said, however, that death from "pleural shock" is less apt to occur in a paracentesis for hydrothorax than in one for pleurisy where the pleura is less normal.

RALPH G. STILLMAN.

Hyères and Costebelle.—Hyères, situated in the department of the Var, is the most southern of all the winter stations along the French Riviera. It is fifty-five miles southeast of Marseilles and seventy-two and a half miles west of Cannes. Unlike the other Mediterranean resorts, it is three miles from the sea, lying at the foot of a steep hill having an elevation of about seven hundred feet. It is sheltered by the mountains from the north and northeast winds, but exposed to the northwest and west winds; hence it suffers, like the other resorts on the coast, from the disagreeable "Mistral," which is especially frequent in February and March. It is less affected by the sea breezes, not only on account of its distance from the sea, but also on account of the protection afforded by the islands lying off the coast—les Isles d'Hyères.

Costebelle, a suburb of Hyères, consisting of a few houses and several hotels surrounded by pine woods, is almost on the coast, so that patients can easily have the change from the more sedative air of Hyères to the more bracing and stimulating atmosphere of the seaside.

The town of Hyères itself contains 17,700 inhabitants, and consists of the old and the new town, the latter being the resort of invalids and visitors—a place where there are villas, hotels, fine avenues, and public gardens.

The winter climate is mild, dry, and sunny, but, as has been said, there exists the one great disadvantage of the cold northwest wind (mistral). "Favorable as I believe this station to be," says Cazalis, quoted by Burney Yeo, "up to the time that the mistral begins to blow, equally dangerous do I believe it to be from that moment." "It is a most searching wind," says Cormack ("The French Riviera—Hyères as a Health Resort," *The Climatologist*, January 15, 1892), "and very trying to invalids and those of a nervous temperament. Patients, as a general rule, are much better at home than out of doors while it lasts."

In looking over the climatic table of Hyères arranged from data of Drs. Biden and Cormack, it will be observed that the mean average temperature for the

months from November to April inclusive, does not vary very much from month to month. Neither do the extremes appear to be very great. The average daily range is large, owing to the rapid fall of the thermometer after sunset, which frequently amounts to as much as seven or eight degrees.

CLIMATIC DATA OF HYÈRES. (From Biden and Cormack.)

	November	December	January	February	March	April	Mean of six months
Temperature—							
Average or normal	53.6°	48.0°	47.5	48.5°	51.0°	55.0	50.7°
Average range	15.6	15.0	16.5	15.9	17.5	16.1	
Mean of warmest..	61.4	55.5	55.8	56.5	59.8	63.3	58.7
Mean of coldest	45.8	40.5	39.3	40.6	42.3	47.2	42.6
Highest or max.*..	63.7	57.5	57.5	57.5	60.0	66.7	
Lowest or min.*...	45.0	40.5	41.2	41.5	44.2	52.2	
Humidity—							
Average or relative	76%	73%	76%	75%	71%	71%	73.5%
Precipitation—							
Average in inches..	3.52	2.86	3.08	2.21	2.26	3.11	17.04
Wind (number of days).							
Light to fresh	10	11	9	11	15	16	74
Strong to a gale	2	5	3	3	3	4	22
Weather—							
Days of sunshine per month.....	21	21	23	20	25	23	135
Days on which rain fell.....	7	6	6	6	5	7	39
Days calm	16	15	18	13	12	9	84

*At midday and 8 A. M.

Between the hours of 8 A. M. and 4 P. M., however, says Cormack, the winter temperature may be said to vary between 50° and 59° F. in the shade, and from 75° to 85° F. in the sun. Occasionally the freezing point is reached. The air is moderately dry, as indicated by the relative humidity, and there are no mists. The rainfall is small, and for the six months rain falls on an average only on thirty-nine days.

There is a very large amount of sunshine, an average of 135 days out of a possible 181 days, or three-fourths. There is an average of twenty-two days of light winds and twenty-two of strong ones. If the winds, especially the mistral, could only be eliminated, this resort, as indeed the others of the Riviera, which in like manner suffer, would be most delightful; but the health resort is yet to be discovered in which every climatic factor is favorable. As has been referred to in the article upon *Cannes*, the climate of the Riviera, in the writer's opinion, is far inferior to that of southern California, with which it is comparable, especially in temperature, dryness, the amount of sunshine, and, more than all, in regard to the winds. Southern California is free from high, cold winds like the mistral. In Southern California we have, moreover, that degree of equability which is nowhere found on the Riviera.

In like manner comparing the Riviera with southern Florida, we find that the climate of the latter possesses that measure of warmth and equability which is not found in the former, and is free from cold winds, though on the other hand, Florida is considerably moister than the Riviera. Speaking in general of the winter climatic characteristics of Hyères, we may say that they are mildness, purity of air, abundant sunshine, and moderate dryness. On the other hand, the chief feature of an unfavorable nature is the "fearful" mistral. "It rakes the valley from end to end, with no obstacle to stop it or turn it; it blows sometimes for six or seven days together, and nights too!" (Cazalis, quoted by Burney Yeo.) Although cold, this mistral is a very dry wind, and a wind which generally brings fine, clear weather. The air loses its humidity and becomes dry, cold, penetrating, and irritating. As has been before noted, it is not frequent until February or March.

The invalid's day, as given by Cormack (*op. cit.*), is comprised between the hours of 10 A. M. and 3 P. M. for the warmest months, and between 11 A. M. and 3 P. M. when the days are colder. At sunset there is a rapid fall of temperature which renders it dangerous for delicate persons to go out after that time. There is also a marked difference between the sun and shade temperatures, so that it is always wise to be provided with a wrap. The vegetation is luxuriant and varied. "The mountains and hills are covered with trees as green in the winter as in the summer." The orange, olive, and palm trees are seen on every hand. Roses, violets, anemones, hyacinths, etc., are sent in great quantities during the winter to the European markets, and early fruit and vegetables are cultivated for the Paris market. There are many charming and picturesque promenades, and in this respect, says Burney Yeo, Hyères is much better off than most other resorts on the Riviera. The outdoor diversions are many and varied; botanizing, butterfly catching, antiquarian research, boating, fishing, golf, tennis, etc., are some of them. The valley in which Costebelle is situated is better sheltered from the mistral, and is "enbosomed in pine woods, broken here and there by vineyards and olive orchards. . . . Near the shore there are large groves of olive trees, which are finer than at Hyères itself, and indicate a warmer climate" (Sparks, "The Riviera"). The water supply of Hyères is said to be good and the sanitary condition satisfactory, except in the old portions of the town. The accommodations are good and abundant.

As to the class of invalids for which the climate of Hyères is beneficial, the testimony is conflicting. Cormack says it is "admirably suited for cases of phthisis," while Drs. Sparks, Weber, and Yeo, says Richards, are rather non-committal. In the writer's opinion, the value of this climate for phthisis is very slight, and while there are so many other resorts of approved value for this disease, he would never think of sending a phthisis patient there, for the reason that the cure cannot be a continuous one on account of the heat in summer, and, secondly, on account of the winds, especially the mistral.

Of other diseases said to receive benefit here, there are mentioned various bronchial affections, liver complaints, Bright's disease, diabetes, asthma, heart disease, rheumatism, gout, neuralgia, some forms of dyspepsia, chronic intestinal catarrh, chronic dysentery, and the feeble condition of delicate children. This resort is also suitable for that large class of the feeble from age or other cause who sustain life with less effort in any mild, sunny climate like this; and, finally, for that class who temporarily are worn out with all the demands of city life, who desire a change, *per se*, and who prefer a place where they can lead a simple life out of doors under sunny skies and in pure air, and devote themselves to rest, and freedom from exacting business or social duties.

EDWARD O. OTIS.

Hygiene of Dwellings.—See *House Sanitation*.

Hygiene of Industrial Establishments.—See *Occupational Diseases*.

Hygiene, Military.—Military hygiene is the science of preserving and promoting health among troops in garrison, camp, and during active field service. In well-established military posts and garrisons hygiene and sanitation differ very little from that of the governmental, state and municipal institutions and colonies of civil life, especially in regard to the well-known measures for the promotion of health and welfare, such as water supply, heating, lighting, ventilation, sleeping space, bathing facilities, disinfection, sewerage and the disposal of wastes.

In view of the above facts, and the limited space

allowed by the publishers, the discussion in this article will principally be confined to the military hygiene and sanitation of camp life and active service in the field.

Recruitment.—Since health and efficiency among troops depend primarily upon the mental and physical character of its personnel, the recruitment of any army becomes one of the most important duties of the military medical officer. Faultless military hygiene, camp sanitation and medical care will never keep troops healthy and fit them to endure the hardships of active field service unless they are endowed with good constitutions and are mentally, morally and physically sound at the time of enlistment.

The marked difference between the morbidity and mortality of regular and volunteer troops, as shown during our various wars in favor of the former, resulted mainly from the difference in the care of their selection and examination. For this reason the admission rate of sickness per 1,000 among the regular troops was fifty per cent. lower than among the volunteer troops during the Spanish American War in many instances, even when occupying the same camps and performing the same character of duty. Colonel Valery Havard, a distinguished American Army surgeon states that during the Civil War the annual mortality from disease and discharges for disability among the volunteers were respectively fifty-five and ninety-one per 1,000, while they were only thirty-two and sixty-eight among the regulars. During the Philippine Insurrection, 1900, the admission rate for disease among the regular troops was 1,821 per 1,000, while among the volunteers it was 2,762 per 1,000. The mortality rates for the two classes were respectively twelve and twenty-five per 1,000.

Greater attention is now paid to the selection and examination of the recruit than ever before in the history of the army, in fact, the recruitment of the soldier is now considered a specialty, which requires the expert knowledge of an experienced army or naval medical officer. From the nature of the duty, as well as from an economic standpoint, it should be apparent to every military man that the recruitment of an army is purely a medical question and should be delegated to the Medical Corps as a part of its regular duties. Recently the War Department has, in a measure, anticipated such a policy by designating officers of the Medical Corps as the recruiting officers of the various recruit depots, posts, and stations of the army.

Under the present system the recruitment of the army is administered by two classes of officers, the medical officer and the line officer, the latter being assigned to the recruiting stations in the large cities, while the medical officers are assigned to the recruit depots, regimental recruit posts and ordinary stations. The line recruiting officer makes the preliminary survey of the candidate for enlistment, and transfers those regarded as suitable to the nearest recruit depot or regimental recruit post, where they are carefully examined by a board of medical officers before enlistment. The officer in charge of the city recruiting station, who is not necessarily a medical officer, is expected to discover all mental and physical defects which should be evident to the experienced officer without professional knowledge on the subject.

Besides variations from the prescribed standards of physical proportions as given in General Orders, War Department, April 18, 1910, the line recruiting officer should detect lack of the free use of limbs and joints, defective vision and hearing, impediment of speech, deformities, defective teeth, depression of the skull from injury, pronounced hernia, varicocele, varicose veins, hemorrhoids, obvious skin and venereal diseases, external tumors or disqualifying cicatrices, bad feet, shortness of breath, palpitation of the heart, and other defects that any experienced officer should detect in a stripped examination. While varicose veins, varicocele, corns, callosities, hammer toes, bunions, and flat feet, if serious, are causes for rejection, the minor degrees of these defects are very common among men who lead active lives, many of whom would make excellent soliders. Flat feet are quite common among the negro race, many of whom are affected to the second degree apparently with no inconvenience.

Officers in charge of city recruiting offices, which may be regarded as the first line in recruitment, are expected also to inquire carefully into the habits and family history of each applicant in order to weed out the alcoholics, narcotic addicts, moral perverts, criminal classes, and those suffering from constitutional weakness or hereditary tendencies.

Unfortunately our system of examination and family investigation is too superficial to detect moral and physical degeneracy in many accepted recruits, who subsequently are found to be alcoholics, narcotic addicts, epileptics, morons, moral degenerates, or men who have previously suffered from some form of mental trouble or have a family history of insanity. It is more than probable that the majority of the above mentioned degenerates, many of whom desert or become garrison or general prisoners, could have been excluded from the army, had a more careful investigation been made of each applicant's history and family by the recruiting officer before enlistment.

The physical examination, which is conducted at the recruit depot or regimental recruit post by the medical officers is regarded as exceedingly thorough and in fact more careful than the examination required for an ordinary insurance policy. A most careful examination is essential for two reasons: first, to secure men who are able to perform active field service under the most unfavorable climatic conditions, and second, to prevent the enlistment of men who may become a burden to the pension list on account of constitutional weakness or disease existing prior to enlistment.

Applicants for enlistment are examined stripped and required to conform in weight, height, and chest measurement to a table prescribed in recruiting regulations. Those under weight, height, and chest measurement as well as the obese are rejected. The sight is tested by means of Snellen's cards adapted to the army, and the hearing by repeating words spoken in a low tone at prescribed distances.

Table of Physical Proportions for Height, Weight, and Chest Measurement Required of Recruits

Height		Weight	Chest Measurement	
Feet	Inches		At expiration inches	Mobility inches
5	4	128	32	2
5	5	130	32	2
5	6	132	32½	2
5	7	134	33	2
5	8	141	33½	2½
5	9	148	33½	2½
5	10	155	34	2½
5	11	162	34½	2½
6		169	34½	3
6	1	176	35½	3

The minimum weight for all branches of the service is 128 pounds, subject to exceptions, but in no case will a recruit under 120 pounds be accepted. The age limits are from eighteen to thirty-five years. No minor enlisted except with consent of parents or guardians. Variations in weight and height are made for the different branches of the service, namely cavalry, artillery, and infantry.

Applicants are put through a series of calisthenic

movements in order to detect defects in muscular and joint movements. After a careful survey of the body, including an examination for hemorrhoids, hernia, enlarged glands, skin and venereal disease, the heart, lungs and abdominal organs are carefully examined. Urinary analysis is rarely made unless there are indications of kidney trouble. No standard is required for the mental examination, but each recruit must be able to read and write and possess a good average mind.

The most common causes for rejection are defective chest development, curvature of the spine, flat feet, bunions, hammer toes, defective sight and hearing, hemorrhoids, syphilis and chronic skin diseases, chronic rheumatism, large cicatrices, varicose veins and varicocele, mutilations of hands or feet, heart and lung diseases, depressions of the skull from injury, alcoholism and general evidence of mental hebetude and vicious tendencies.

Physical Development and Setting-up Drill.—Regular physical exercises, or the setting-up drill, immediately follow the enlistment of the raw recruit in order to give him the proper military bearing so necessary in the appearance of the well-disciplined soldier, as well as to develop his muscular system so as to bring out to the fullest his powers of endurance. From time immemorial "setting-up" exercises have been practised in all armies to correct the physical defects of careless habits so commonly observed among non-military men. A few months of well-regulated military exercise, as a rule, transforms the uncouth slouchy recruit into an erect, square-shouldered active soldier, and gives him an appearance and military bearing entirely at variance with the commonality of men. Besides the effect of the "setting-up drill" on the general appearance and muscular development of the soldier it disciplines the mind and makes him more ready to respond to commands.

The well-disciplined and drilled soldier should always preserve a physical condition which would enable him to undergo forced marches and the hardships of campaigns at all seasons of the year and in every climate provided he is subjected to proper sanitary regulations. From experience military men have learned that soldiers unaccustomed to systematic training have little endurance and soon fall out on the march. Such men in a short time find their way to the ambulance train and become the most undesirable impedimenta connected with an army in the field.

Daily calisthenic exercises for a half hour or hour daily is of the greatest value to every one in keeping the muscles under perfect control, the intestines and abdominal organs active and the body inconvenienced by surplus flesh. Practice in deep breathing should also find a place in the physical exercises of soldiers because in calling the respiratory muscles into enforced action oxygenation of the blood is increased and the general health improved. Regular military calisthenics should be held in the open air when possible and not continued more than one hour, with proper intervals.

When the weather is rainy or too inclement the exercises should be given in barracks or the gymnasium, but never long enough to tire the men. Besides they should be varied each day as far as possible to make them interesting and acceptable. Young soldiers should be carefully watched and not overexercised since overtraining is liable to result in injury, especially to the heart. The symptoms of over-training are muscular pains, headache, gastric disturbance, insomnia, and general stiffness.

The United States Army has adopted a Manual of Calisthenic Exercises and a Manual of Gymnastic Exercises prepared by First Lieutenant H. J. Koehler, U. S. A., Senior Instructor of Military Gymnastics at the United States Military Academy, West Point, N. Y. Besides these two excellent manuals a manual of Physical Drill prepared by Captain Edmund L. Butts, U. S. A., has been made official and issued our troops. The exercises contained in the Manual of Calisthenics practically involve all of the muscles of the body and are arranged in the form of commands for squads or companies. The instruction in the Manual of Gymnastics embrace vaulting horse, horizontal bar, parallel bars, rings, ladders, climbing poles, and jumping. In addition to out-door drills and exercises the men are required to attend gymnasium practice at posts provided with gymnasia. Exercises in the gymnasium is especially required during winter months or rainy season when exercise in the open is not possible

Butts' Manual, which is quite popular and largely used in the Army, embraces rifle, bar-bell, and dumb-bell drill, in addition to the usual gymnasium and rope exercises, besides athletic games and contests The exercises and movements are well described and the manual excellently illustrated. Butts' rifle drill is adapted to the use of a squad, company, battalion, or regiment and is very effective when accompanied by the regimental band. Men who have been in service from fifteen to twenty years are too old, as a rule, for the rifle drill and should be excused. This drill admits of a great variety of movements and cannot fail to be attractive and useful. (See Plate XXXIX.)

During the various calisthenic exercises and drills the men should be permitted to wear the cap, olive drab shirt, regulation trousers, leggins and shoes. In barracks or gymnasium they should be permitted to wear the regular gymnasium shoes.

Uniform and Clothing.—The uniform and clothing of the United States Army have undergone many radical changes since the war with Spain in 1898. In place of the dark blue woolen blouse and sky blue trousers, which were worn at that time for field, as well as garrison duty, both in winter and summer,

Articles	Year.				
	First.	Second.	Third.	Fourth.	Total.
Breeches, service (woolen)	3	2	1	1	7
Breeches, cotton	2	1	1	1	5
Caps, dress	1	1			2
Caps, service	1	1	1	1	4
Coats, fatigue	2	1	1	1	5
Coats, dress	1		1		2
Coats, service, cotton	3	1	1	1	6
Coats, service, woolen	2		1		3
Collars	14	8	8	7	37
Cords, breast	1				1
Drawers	6	3	3	3	15
Gloves, white cotton	8	3	3	3	17
Gloves, wool, olive drab	1	1	1	1	4
Hats, service with cord	1	1		1	3
Leggins, canvas	3	1	1	2	7
Shirts, olive drab flannel	3	1	1	1	6
Shoes	4	2	2	2	10
Stockings, cotton	8	4	4	4	20
Stockings, wool, light weight.	6	2	2	2	12
Suspenders or waist belts	1	1		1	3
Trousers, fatigue, dismounted.	2	1	1	1	5
Trousers, dress	1	1		1	3
Undershirts, cotton or winter	6	3	3	3	15

an olive drab woolen blouse with breeches and leggins have been adopted for winter, and a dark olive drab cotton blouse and breeches with leggins for summer, and duty in the Philipines, Porto Rico and the Canal Zone. There has been a general movement among all of the great world powers to modify the service and field uniform with a view to comfort, health, simplicity

BUTTS' RIFLE DRILL

and inconspicuousness in the field, instead of following regimental traditions which had forced upon certain organizations an obsolete and gaudy dress worn more than a century or more ago.

The service colors, olive drab and dark khaki, have been found more practical in the field in every respect and possess the great advantage of inconspicuousness during an engagement, which was made necessary on account of the long range of the modern rifle. Besides the advantage of invisibility to the enemy and quality of not showing dirt as readily as the dark uniform the present service colors are much cooler during warm weather since these neutral tints absorb less heat from the sun's rays. An olive drab sweater is used for field service over the flannel shirt when necessary instead of the blouse.

The preceeding table of allowance shows the clothing in kind for each enlisted man during his four years of active service.

For the payment of the above articles of uniform, besides cap and collar ornaments, each soldier is allowed $149.21 during the four years of active service, which is sufficient to purchase the clothing allowance during that period. Heavy olive drab woolen overcoats, olive drab sweaters for field service, ponchos and slickers are issued soldiers on memorandum receipts.

The dress suit which consists of a dark blue blouse with service or corps facings and breast cord, sky blue trousers and dark blue cap is used by the enlisted men for parades, guard mounting and special ceremonies, when prescribed by the commanding officer.

The shape of the present service hat, Montana Peak, is not as satisfactory as the old shape, the Alpine, issued several years ago, principally because the brim is stiff and crown soon loses its shape.

The army is now provided with an excellent field and garrison uniform which meets with all of the requirements of health, comfort, and service. The under-clothing and shoes are excellent and have been adopted after careful investigation and trial. Experiments were made with orange colored underclothing in the Philippines a few years ago to determine whether the actinic rays of the sun caused sickness among the troops and a general lowering of the health. Orange colored cotton underclothing was worn by one or two regiments for a year, with no appreciable difference in the health conditions of the men. Abdominal bands or protectors were also used for the prevention of intestinal disturbances among our troops in the tropics. They were difficult to retain in position and their use has been generally discarded.

The regulation russet leather shoe, now worn for all occasions, was adopted on the recommendation of the Munson shoe board, and meets all of the requirements for garrison or marching duty. It is broad across the ball of the foot, has a wide sole and soft toe cap, and laces snugly around the ankle. Besides the service shoe, a gymnasium shoe is issued to the enlisted men.

Soldier's Field Equipment. Every infantry soldier carries on his person in the field a blanket roll, haversack, canteen and cover, besides his rifle, bayonet and scabbard, belt and 100 rounds of ammunition, tin cup and first aid package. Besides these each squad carries one hand-axe and carrier, one pick mattock and carrier, one wire cutter, three shovels and carriers. Each soldier is also required to have a

Fig. 3305.—Infantry Soldier Equipped for the Field. Side and rear views.

surplus kit of clothing which is transported by wagon.

The blanket roll contains one blanket, one poncho, five tent pins, one length of rope, and one-half shelter tent. The haversack contains one towel, piece soap, comb, tooth brush, meat can, knife, fork, spoon, one condiment can with space for coffee, sugar, salt and pepper, and one pair light woolen socks. The surplus kit contains one extra pair marching shoes, one extra pair lacers, two pairs light wool socks, one pair underdrawers, one undershirt, and one sweater.

The personal equipment carried on the march by each infantry soldier weighs forty-eight pounds.

Rations and Food.—The selection of a suitable ration for the army has been the subject of official investigation and study from the organization of the first continental troops to the present day, and it is more than doubtful whether the problem will ever be settled to the entire satisfaction of military authorities on account of the irregular life of the soldier, including as it does such a variety of service and climatic conditions.

Professor Atwater says: "The ideal diet is that combination of foods which, while imposing the least burden on the body supplies it with exactly sufficient materials to meet its wants." Professor R. H. Chittenden, one of the greatest authorities on the subjects of foods, claims the ideal diet to be the smallest amount of proteins, fats, and carbohydrates sufficient to establish and maintain the physiological and nitrogen equilibrium, to keep up that strength of body and mind essential to good health, to maintain the highest degree of physical and mental activity with the smallest amount of friction and the least expenditure of energy, and to preserve and heighten the ordinary resistance of the body to disease germs.

Professor Chittenden devoted many years to the study of maintaining the so-called nitrogen equilibrium in professional men, athletes and soldiers, and concluded that the proper daily diet for a man weighing 154 pounds should not exceed sixty grams of proteids with enough fats and carbohydrates to make up a total fuel value not exceeding 2,800 calories.

A ration is the allowance for the subsistence of one person for one day, and may consist of the garrison ration, field ration, reserve ration, travel ration, emergency ration and Filipino ration. The garrison ration, which forms the bases of the others, except the emergency ration, is intended for troops serving in garrison, maneuver camps and other occasions, in time of peace, where practicable. The kinds and quantities of the component articles of the garrison ration and the substitutionequivalent articles, which may be issued in place of such component part is as shown above:

1 Garrison Ration.

Component articles and quantities			Substitution articles and quantities		
			Mutton, fresh	20.0	ounces
			Bacon	12.0	ounces
			Canned meat	16.0	ounces
			Hash, corned beef	16.0	ounces
Beef, fresh	20.0	ounces	Fish, dried	14.0	ounces
			Fish, pickled	18.0	ounces
			Fish, canned	16.0	ounces
			Chicken or turkey, fresh	16.0	ounces
			Soft bread	18.0	ounces
Flour	18.0	ounces	Hard bread	16.0	ounces
			Corn meal	20.0	ounces
Baking powder	0.08	ounces			
Beans	2.4	ounces	Rice	1.6	ounces
			Hominy	1.6	ounces
			Onions	20.0	ounces
Potatoes	20.0	ounces	Tomatoes (1)	20.0	ounces
			Other fresh vegetables.	20.0	ounces
			Apples, evaporated.	1.28	ounces
Prunes	1.28	ounces	Peaches, evaporated.	1.28	ounces
			Jam	1.28	ounces
Coffee, roasted and ground.	1.12	ounces	Coffee, green	1.4	ounces
			Tea	0.32	ounces
Sugar	3.2	ounces			
Milk, evaporated.	0.5	ounces			
Vinegar	0.16	gill	Pickles, cucumber in lieu of vinegar, not exceeding 50 per cent. total issue		
Salt	0.64	ounces			
Pepper, black	0.04	ounces			
			Cloves	0.014	ounces
Cinnamon	0.014	ounces	Ginger	0.014	ounces
			Nutmeg	0.014	ounces
Lard	0.64	ounces	Lard substitute	0.64	ounces
Butter	0.5	ounces			
Sirup	0.32	gill	Vanila	0.014	ounces
Flavoring ext., lemon	0.014	gill			

The garrison ration weighs four pounds and five ounces.

Field and reserve rations.

	No. 1.	No. 2.	No. 3	Reserve ration.
Beef, fresh		14.0 oz.	14.0 oz.	
Mutton, fresh				
Bacon	12.0 oz	3.16 oz	3.6 oz	12.0 oz
Canned meat				
Fish, dried				
Fish, pickled				
Fish, canned				
Chicken or turkey				
Flour				
Hard bread	16.0 oz			16.0 oz
Corn meal				
Bread		16.0 oz.	16.0 oz.	
Baking powder				
Beans	4.0 oz.	4.0 oz	4.0 oz.	
Rice				
Hominy				
Potatoes		14.0 oz.	14.0 oz.	
Onions			2.0 oz.	
Tomatoes	10.0 oz	5.0 oz.	2.0 oz	
Other fresh vegetables				
Prunes	1.28 oz	1.28 oz.	0.384 oz	
Apples, evaporated			0.128 oz.	
Peaches, evaporated			0.128 oz	
Jam			0.64 oz.	
Coffee, roasted, ground	1.28 oz.	1.12 oz.	1.12 oz.	1.12 oz.
Coffee, green				
Tea				
Sugar	2.4 oz.	2.4 oz	3.2 oz.	2.4 oz.
Milk, evaporated				
Vinegar			8.0 gill	
Pickles				
Salt	0.16 oz.	0.16 oz.	0.64 oz.	0.16 oz.
Pepper, black		0.02 oz.	0.04 oz	
Cinnamon				
Other spices				
Lard			0.64 oz.	
Substitute for lard				
	2.935 lb.	3.85 lb.	4.0 lb.	1.98 lb.

Nos. 1 and 2 are adapted for use of troops in campaign. No. 1 embraces all the components of the ration; No. 2 contemplates that fresh beef and fresh vegetables may be furnished troops directly. No. 3 provides a more varied diet and is adaptable when troops are located near depots or supply. In computing carrying capacity of supply trains, weight of ration including container taken at three pounds. One day in each month of the season of practical instruction, not exceeding three days in each year, the use of the reserve ration with individual cooking will be required by all troops in the field for purposes of instruction.

1. Onions, tomatoes, and other fresh vegetables may be issued in lieu of an equal quantity of pota-

toes, but not exceeding twenty per cent. of the total issue. In Alaska the allowance of fresh vegetables will be twenty-four ounces instead of twenty ounces, or canned potatoes eighteen ounces instead of fifteen ounces. Food for troops traveling on United States Transports will be prepared from articles of subsistence stores which compose the rations for troops in garrison, varied by the substitution of other articles of authorized subsistence stores, the total daily cost per man of food consumed not to exceed twenty per cent. more than the current cost of the garrison ration, except on Thanksgiving Day and Christmas when sixty per cent. increase over the same current cost is authorized.

Travel Ration

Component articles and quantities		Substitution articles and quantities.	
Soft, bread	18.0 oz	Hard bread	16 oz
Beef, corned	12.0 oz	Hash, corned beef	12 oz.
Beans, baked	4.0 oz.		
Tomatoes, canned	8.0 oz.		
Jam	1.4 oz.		
Coffee, roasted, ground	1.12 oz.		
Sugar	2.4 oz.		
Milk, evaporated, unsweetened	0.5 oz.		

The travel ration is for troops traveling otherwise than by marching and separated from cooking facilities; the reserve ration is carried on the person of the men and in trains, and constitutes the reserve for field service. The field ration is the ration prescribed by the commander of the field forces. Besides the garrison, field, reserve, and travel ration the government has adopted a ration for the use of the Filipino scouts.

Filipino Ration.

Component articles and quantities.		Substitution articles and quantities.	
		Bacon	8 oz.
Beef, fresh	0.12 oz.	Canned meat	8 oz
		Fish, canned	12 oz.
		Fish, fresh	12 oz
Flour	0.8 oz.	Hard bread	
		Soft bread	
Baking powder	0.32 oz.		
Rice, unpolished	0.20 oz.		
Potatoes	0.8 oz.	Onions	8 oz.
Coffee, roasted and ground	1.0 oz.		
Sugar	2.0 oz.		
Vinegar	0.08 gill		
Salt	0.64 oz.		
Pepper, black	0.02 oz.		

Scout company commanders are authorized to purchase 1.6 ounces of beans in substitution for rice ration not drawn. They will purchase native products such as camotes, mangos, and squash. In time of war when Philippine Scouts are serving in the field they will be subsisted the same as regular troops.

Emergency Ration.—Considerable effort has been directed to the preparation of a concentrated or emergency ration to be used on forced marches or occasions where the ordinary field ration was not procurable. A number of different formulæ have been devised by the various armies of the world but none have been found entirely satisfactory. Several years ago the United States adopted an emergency ration, consisting of three wheat and meat cakes, three chocolate cakes, salt and pepper, put up in a hermetically sealed khaki colored lacquered can with key opener. This contained three meal rations, weighed twelve ounces net and according to Professor Langworthy had a fuel value of 1,500 calories. Colonel Havard offered as an objection to this ration that it required special plants for its preparation and that in case of mobilization on a large scale the supply would utterly fail. Later an emergency ration was devised which contained the following food components: 45.45 per cent. chocolate liquor; 7.27 per cent. casein, equal to nucleocasein; 7.27 per cent. malted milk; 14.55 per cent. egg albumen; 21.82 per cent. powdered cane sugar; 3.64 per cent. cocoa butter (percentage of moisture not to exceed three per cent). All of the components to be of the best quality and to be subject to inspection and approval at each stage of manufacture. Each ration consisted of three cakes of equal size and weighed eight ounces net. They were wrapped in paraffin paper and tin foil, and packed in hermetically-sealed round-cornered tins which were thoroughly lacquered. This ration did not prove satisfactory or acceptable to the men and has been discontinued. At the present time the United States Army has no officially recognized emergency ration.

Peddlers and Hucksters.—Peddlers and hucksters vending soft drinks, pies, fruits, and other articles of diet should be prohibited from camp. The sale of such articles should be limited to company and regimental exchanges, where they can undergo careful supervision. The promiscuous sale of such foods and drinks is a menace to the health of the command and liable to produce intestinal disturbances, indigestion, and even typhoid fever in those not protected by typhoid vaccination. The source of the milk supply should be carefully examined by the medical officer and prohibited from dairies uncleanly or improperly kept.

Field Cooking and Baking.—Theoretically every soldier is expected to be capable of preparing his own food in the field and is provided with an individual frying pan or "meat can" for this purpose. The meat can is made of heavy block tin with cover and hinged folding handle, and is intended both for a frying pan and dish. Besides the meat can, each soldier is furnished a knife, fork, spoon, and tin cup as part of his individual field kit. The government provides each company in garrison with an excellent army range and a complete set of cooking utensils. Company kitchens are also equipped with ice boxes, refrigerators, vegetable bins, dish closets, tables, and the ordinary furniture found in all well regulated kitchens.

For the field each company is furnished an army field range No. 1 with set of cooking utensils, which has a cooking capacity for 150 men. The company field range is made of heavy sheet iron, weighing 264 pounds including utensils, and consists essentially of two parts, the oven and boiling plate. The boiling plate has three sections which are shown in Fig. 3306. On the march the range is ordinarily set up by leveling the ground and placing the oven and boiling plate side by side so that the oven door and fire box will be at the same end. Besides Army field range No. 1, a smaller size, No. 2, is furnished to cook for 55 men. This range weighs about 150 pounds and is not provided with the Alamo attachment. It consists also of two parts, the oven and boiling plate and is practically installed the same as No. 1.

Many practical methods of preparing food in the field are employed by experienced soldiers, when it is impracticable to take the field range on account of limited transportation. In such cases it will become necessary to prepare the food in a more primitive style. On such occasions Dutch ovens, camp kettles, or the meat can and tin cup are usually employed. An improvised kitchen may be easily constructed by digging a trench four feet long and one foot deep in the direction of the wind with a chimney at the windward end made of stone, sod or mud. The trench should be several inches less in width than the kettles. If the material be at hand the trench may be closed leaving several holes along its course for

camp kettles. On one side of the kitchen a "wind break" should be built of brush, branches of limbs or shelter tent half (Fig. 3307).

A very primitive but serviceable kitchen may be made by laying two logs, eight to ten inches in diameter, parallel and just far enough apart to form a rest for the bottom of the camp kettles. In place of the logs a ditch from four to six feet long one foot deep and eighteen inches wide will serve as an excellent fire bed. The kettles can be suspended above on a sapling supported by forked sticks. Although the Army field range contains an oven it is not intended for baking the bread component of the ration. Soft bread is issued to troops in the field when practicable, otherwise hard bread is served. In permanent or semi-permanent camps the Army field oven is employed for baking the bread. The regimental field oven No. 1, has a capacity for baking 216 rations and 1,000 if kept in operation during the twenty-four hours. Field oven No. 2 has a capacity of 240 rations and weighs 1,232 pounds. The weight of this oven and equipment is about 2,607 pounds.

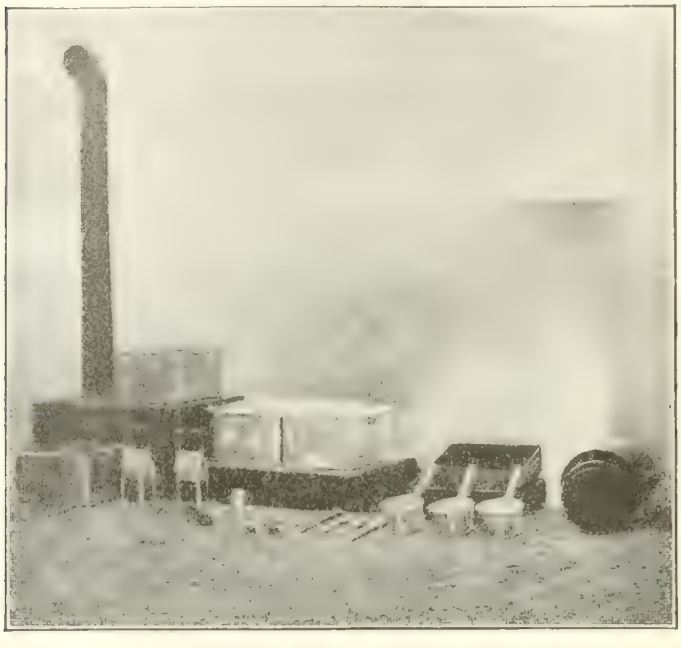


Fig. 3306.—New Army Range.

Fig. 3307.—Improved Field Kitchen.

A school for bakers and cooks has been established at Fort Riley, Kansas, for a number of years to which men are sent for instruction in this most important duty. The government has also organized Bakery companies for war service. They are formed from enlisted bakers of the Quartermaster Corps, with such civilians as may be necessary. Each company is divided into four sections A, B, C, and D, of three units each, and is intended to bake bread for one Division. Bakery companies are equipped with sixteen ovens besides the other equipment and necessary tentage. The company may be separated into units or sections. One unit is supposed to be able to serve one regiment and one section one separate brigade The bakery company at peace strength will consist of three organized sections and one unorganized section. The equipment of the fourth section, however, is to be kept on hand.

Fig. 3308.—Army Field Baking Oven, No. 1

Personnel, Bakery Company, War Strength.—Commissioned officer, 1; chief baker, 1; assistant chief bakers, 4; bakers, 20; assistant bakers, 32; cooks, 2; cooks or general police, 2; total, 62.

Water Supply and its Purification.—A pure and satisfactory water supply is probably the most important, as well as the most difficult problem, connected with the sanitation of troops during active military service in time of war, or during field maneuvers and practice marches in time of peace. The water supply of permanent posts or garrisons, which are located in or near cities and towns, is usually drawn from the municipal system, while the supply for remote posts is taken from fresh water streams, springs or driven or artesion wells, whose quality and quantity were investigated before the location of the post. A few military stations still use rain water, which is collected in cisterns, or water hauled from springs at a distance, or distilled from salty or brakish wells.

Great attention is always paid to the water supply by modern military sanitarians on account of its important bearing on the health and efficiency of the troops. It has been said that on account of its great importance in Manchuria during the Russo-Japanese War the commanders of Japanese troops sent out sanitary scouting squads equipped with microscopes and reagents, to test possible supplies and condemn and mark those found polluted. Guarding the water supply is one of the most important duties for the

safety of a command in the field. Sentinels should be posted and stringent measures used to punish any one caught in violating sanitary regulations for its protection.

The investigation of water for drinking purposes demand an examination into the following conditions: (1) Organic and inorganic matter; (2) pathogenic microorganisms; (3) parasites and microscopic life.

The determination of organic matter in water is of greater importance than the determination of its mineral constituents and requires chemical appliances and agencies. A simple test is the "combustion process" which can be made by evaporating a given quantity of water in a platinum dish after weighing, and ascertaining the loss of weight by ignition. The blackening of the capsule and odor given off during the process have an important bearing on the amount of contamination.

The percentage of free ammonia and albuminoid ammonia are determined by the Nessler process, which requires careful distillation, and use of the standard Nessler tubes and solutions. According to Wanklyn, water containing over 0.15 of albuminoid ammonia per million should be condemned. An excess of free ammonia or albuminoid ammonia indicates active decomposition and is always a suspicious sign. The maximum limit proposed by Leeds are: Free ammonia 0.01 to 0.12 per million; albuminoid ammonia 0.10 to 0.28 per million.

Nitrates in water indicate active fermentative changes and invite suspicion. The nitrates indicate the completed process of the oxidation of nitrogenous organic matter and contamination at some previous time. Chlorine is generally found in water and is harmless when not in excess. The hardness of water, which is common in limestone regions, in moderation, is not material and results from the solubility of alkaline salts, lime, magnesia, baryta, alumina, and other minerals. Soft water results from passage through silicious rock or rains. Hard water may be more or less softened by boiling or the use of ordinary washing soda. Carbon dioxide (CO_2) is expelled by heat and the bicarbonates transformed into simple carbonates which are precipitated. The addition of washing soda sets up a reaction and creates sodium bicarbonate and the carbonate of calcium.

Practically all natural waters contain bacteria which vary greatly in number and variety, according to place or condition. Besides pathogenic organisms water contains many forms of bacteria, saprophytic in nature, and probably more beneficial than harmful. The principal dangerous and harmful organisms found in drinking water are the bacillus of typhoid fever, cholera, bacillary dysentery, amebic dysentery, and the bacillus coli communis. The colon bacillus is very widely distributed, but finds its normal habitat in the intestine of man and other animals.

The sanitary significance of colon bacilli varies with their number, but indicates pollution. As a rule, ground water which contains the colon bacilli should be condemned for drinking purposes. The fermentation test is employed as a rule to detect the presence of colon bacilli. A small quantity of the suspected water is planted in lactose bile or lactose bouillon in fermentation tubes and incubated at 40° C. The absence of fermentation and gas indicates absence of the bacilli, while the contrary indicates their presence. Both of these conclusions at times are misleading on account of the preponderance of other nonactive species, while, on the other hand, many organisms other than the colon bacillus found in water, ferment sugar with gas production. Before labeling it *Bacillus coli* a pure culture of the suspected organism should be made and passed through the well-known tests.

The search for the typhoid bacillus is very difficult on account of their comparative fewness. There are several organisms in water closely resembling the *B. typhosus*, some of which give pronounced agglutination with specific serum. With the use of modern methods and Endo's medium they may be isolated from *B. proteus*, *B. fluorescens*, and even *B. coli* which sometimes agglutinate with typhoid serum. The cholera vibrio may be detected in water by making a Dunham's solution of the water itself. The bacillus of bacillary dysentery closely resembles the typhoid bacillus but differs from the latter, inasmuch as it has limited or no motility. More fundamental differences are found in its biological properties, such as specific agglutination and pathogenic poison.

There are two well-recognized types of *B. dysenteriæ*, one corresponds to Shiga's bacillus discovered in 1897 and one found by Flexner in Manila several years later. There are marked differences between the amebic and bacillary types of dysentery; the former starts insiduously and is characterized by relapses and recurrences or a chronic condition associated with intestinal ulcers, liver abscess and extreme emaciation. Bacillary dysentery, on the other hand, is an acute affection usually self limited with marked symptoms of toxemia and frequently epidemic. Amebic dysentery is of common occurrence in the tropics, and is due to an animal parasite of minute size in the form of a round mass of living substance, endowed with motion, through which it enters or envelopes cellular structure causing ulcers and intestinal hemorrhage.

Besides the above mentioned bacilli and ameba drinking water may be polluted with streptococci, the eggs of intestinal parasites such as ascaris, oxyuris, tricocephalus, tenia, ankylostomum, etc. Drinking water may also contain many forms of cryptogamic life, such as fungi, algæ, desmids, diatoms, sponges, infusoria, etc., which have little bearing on its sanitary value, beyond the disagreeable odors they may produce.

The methods employed for the purification of water embrace: (1) Chemical treatment. (2) Boiling and distillation. (3) Filtration. Chemical agents purify water by the oxidation of its organic matter and microbes or by the precipitation of its matter in suspension. Permanganate of potassium has been used many years for the purification of water and has proven more or less satisfactory. One grain to a quart of water is added to the suspected water until a pinkish tinge remains for about thirty minutes. Filtration is recommended afterward to remove the precipitate. Bromine, according to Shumburg's method, and iodine, according to Vaillard, have also been employed for the chemical purification of water. Alum, sulphate of iron and alum, metallic iron, and the sulphate of copper have also been used for this purpose. Ozone is one of the best chemical agents known, but is not available for fluid purposes at present on account of the complexity of the necessary apparatus.

Chlorine in the form of bleaching powder has become a popular and efficient method recently and depends upon the liberation of oxygen, which takes place in the water. The calcium hypochlorite combines with the CO_2 to form calcium carbonate and the liberated chlorine unites with the water to form HCl thus liberating the oxygen which accomplishes the destruction of the bacteria. Clark and Gage have shown that better results were obtained by using about 0.9 grain sulphate of alumina and about 0.7 grain of soda per gallon in combination with bleaching powder, equivalent to 0.11 part per 100,000 available chlorine, than when nearly double the amount of sulphate of alumina and soda were used without the disinfectant.

Major William Lyster, Medical Corps, U. S. Army, has devised a canvas bag for the purification of water by means of the chlorine process, which should prove valuable for field service. It is made of closely woven flax and is twenty-eight inches deep by twenty inches wide, and holds when filled, 38.05 gallons of water. To a hinged metal ring at the top are attached two pieces of quarter inch rope by which the bag is

suspended. Near the bottom seam are five faucets. The bag is folded into a small package weighing five and one-half pounds, which can be carried on the soldier's pack or the cantle of a saddle.

Sixty hermetically sealed amber glass tubes containing approximately one gram each of calcium chloride with a thirty per cent. chlorine strength are packed in corrugated paper and weigh eight ounces. This provides twelve days allowance of purified water for each infantry company at war strength, five canteens of water per diem per capita. One tube is sufficient to purify one bag full of the water. The ordinary pathogenic bacteria are killed in five minutes and a little longer for ameba. The strength of solution is one part of chlorine to 500,000 parts of water. This can be reduced at discretion.

Boiling as a means of purification is practical and satisfactory and can be accomplished with a camp kettle, cauldron, or tin cup if nothing better be provided. A large portion of the drinking water furnished the regular and volunteer troops during the Insurrection in the Philippines, 1898–1902, was prepared in this way. Boiling destroys disease-producing organisms and renders it safe, although the process renders it flat and less palatable by depriving it of the natural gases. This can in a measure be restored, however, by shaking or pouring backward and forward for a few minutes in two vessels. The Field Service Regulations of 1910 required commanders to boil the drinking water for twenty minutes when there was a doubt of its purity.

The Forbes sterilizer was officially adopted for field service in 1898 after competition tests by an Army board, but it has been more or less superceded recently by the Darnall Filter. The Forbes Sterilizer has proven very satisfactory for many years both in camp and on the march. In some of the large camps of maneuver unsupplied with a water system ten or twenty of the Forbes sterilizers were assembled under one shed and operated for the entire command by members of the Hospital Corps under the direction of a medical officer. The processed water was hauled in water wagons daily to the barrels of the various organizations. The Forbes sterilizer is encased in a steel jacket, weighs about ninety-six pounds, and is easily transported. One quart of kerosene oil will last as fuel for three hours. The output varies from fifteen to twenty gallons per hour. Colonel Havard sums up its advantages as follows: (1) The water is not deprived of its natural gases. (2) All living microorganisms are destroyed, except a few harmless spore-bearing bacteria. (3) It may be kept in action for twenty-four hours without renewing the supply of oil in the reservoir. (4) The water flows out of the apparatus only $4\frac{1}{2}°$ F. warmer than when it entered it. (5) It is easily taken apart, cleaned, and put together again. (6) It is durable, not liable to breakage, and very easily transported.

The Forbes Company has also constructed an Army Wagon sterilizer, consisting of boiler, pump, filter, sterilizing and storage tank mounted on wheels. It filters and sterilizes 300 gallons per hour and has a storage tank of 150 gallons. In England the Griffith sterilizer is highly spoken of and well adapted to military purposes. The German Henneberg Trinkwasser wagon and the French Vaillard-Desmaroux outfit are said to give splendid satisfaction in the field.

Among the various processes employed for the purification of drinking water none affects the taste and flavor less than that of filtration. Boiling usually leaves the water flat and insipid, while chemical purification imparts the taste of the chemicals used. Filtration is simply the mechanical process of straining, whereby turbidity, sediment and microorganisms are removed. Our military authorities have tried for many years to secure a satisfactory portable filter, suitable for large or small bodies of troops in the field. A number of devices for this purpose were tried during and since the Spanish War, among which may be mentioned the Maignen, Berkefeld and Pasteur-Chamberland.

The Maignen filter serves an excellent purpose for the clarification of water, and is convenient both for field and camp, especially when the filtrate is passed through the Berkefeld or Chamberland subsequently. The Maignen possesses a core of asbestos felted cloth, surrounded by a layer of charcoal or charcoal compound. The operation is simply a process of syphonage. When muddy water is clarified, the core should be frequently washed and dried. A solution of permanganate of potash, 1–1,000 should be passed through the filter. The Berkefeld filter consists of a hollow bougie made of infusorial earth and enclosed in a case of metal or glass (Fig. 3309). The filtering cylinder is closed above and empties below into a nozzle. With a pressure forty pounds exerted on three cylinders, diameter six inches, the yield per minute is one and one-half gallons. The cylinder clogs rapidly with muddy water and requires frequent cleaning. The reports from medical officers show that the results have not been uniform although Sternberg states that under a pressure of twelve pounds attached to a faucet no bacteria passed through for twenty-one consecutive days. The bougies should be frequently cleaned during the filtration

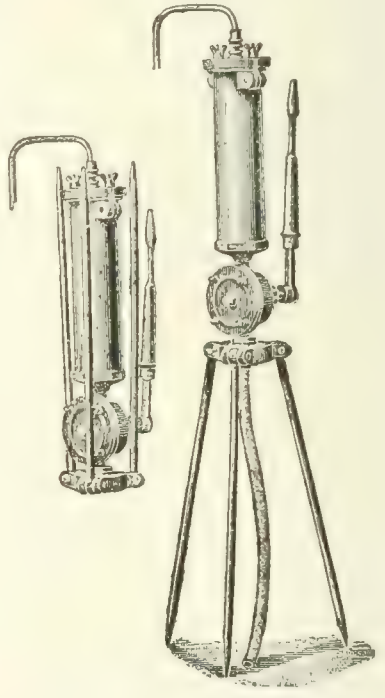


Fig. 3309.—Berkefeld Filter.

of turbid water. A large size Berkefeld filter containing nine cylinders has been fitted up for field service, suitable for mule-back transportation.

The Pasteur-Chamberland filter is similar to the Berkefeld, the essential difference being in the character of the bougie, which is composed of unglazed porcelain instead of infusorial earth. The Pasteur-Chamberland filter renders water more sterile than the Berkefeld but clogs up more readily and requires more frequent cleansing. The portable Chamberland autoclave, as adopted by the French army has not proven practical or satisfactory for field service. With care it serves an excellent purpose in garrison.

The Darnall filter, devised by Major Carl R. Darnall, Medical Corps, United States Army has been adopted for field use in our service and has given general satisfaction. Through its use water is completely

clarified and a bacterial efficiency of ninety-eight per cent. with ordinary water obtained. It consists of a galvanized oval iron tank, two water cans, a syphon filter with cloth and a small syphon pump to start the water.

The essential part of the filter is the cylindrical metal frame of the syphon over which is wrapped the filtering cloth made of closely woven cotton fabric. This is placed in one of the tanks filled with raw water, which previously has been processed with a precipitant consisting of alum and sodium carbonate in such proportions as to neutralize each other. Each gallon of water filtered will contain about 2.5 grams of sodium sulphate, 0.93 of potassium sulphate and 0.7 carbon dioxide, which are harmless, in addition to its previous chemical constituents. For use with troops in the field it is more convenient to use a powder of alum and soda, one pound of which is sufficient for 500 gallons of water. When the flow of water diminishes the cloth should be taken out, brushed, washed and dried and a fresh one used. The new cloth may be sterilized

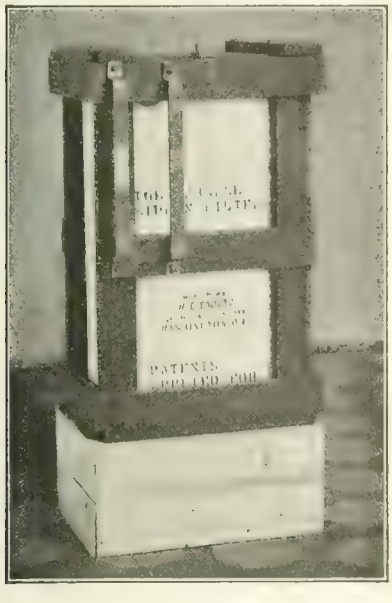


Fig. 3310.—Darnall Filter, Packed.

in the can by syphoning boiled water through it. The Darnall filter weighs fifty-two pounds and will deliver about 200 gallons in four hours. On account of its weight and size it is easily transportable on burros or mules.

In the field it often becomes necessary to improvise filters, especially to clarify water before sterilizing by heat. This can readily be accomplished by the barrel filter which is made of two barrels one of which is smaller, or a barrel and keg (Fig. 3312). The floor of the larger barrel is covered with pebbles or gravel as a foundation for the smaller to rest upon. Holes are bored in the bottom of the smaller one and the space between filled with charcoal and sand. The filtered water will seek its level in the inner barrel. The water supply should be carefully guarded in the field to prevent contamination by as many sentries as may be necessary. Water closets and corrals should especially be located with a view of the safety of the water supply in the field. In camps of maneuver or semi-permanent camps each company should be provided with a twenty-gallon water can equipped with faucet and cover.

Drinking Water on the March.—It is the consensus of opinion among military sanitarians that the least amount of water drunk on the march consistent with ordinary comfort is best for the soldier. Free drinking during a hot, dry day on the march usually produces profuse perspiration, gastric disturbance, and is decidedly debilitating. Recruits and young soldiers

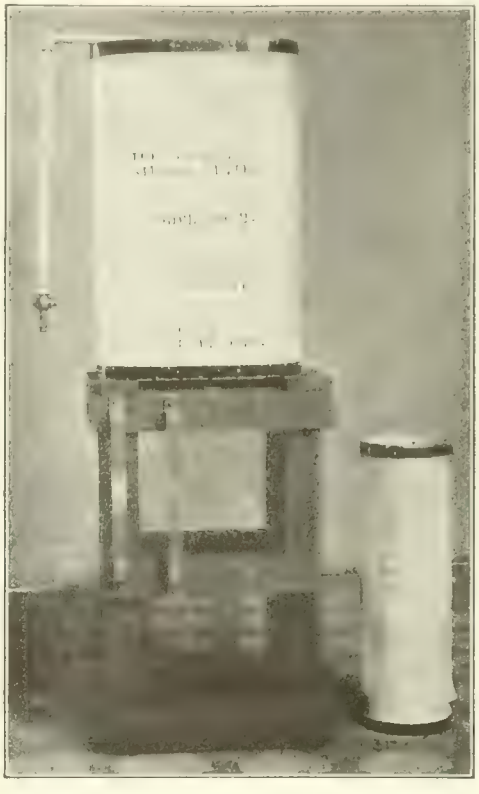


Fig. 3311.—Darnall Filter in Operation.

are prone to empty their canteens before they are out an hour on a hot day. The men should be taught to drink all the water they desire before leaving camp and merely sip enough from their canteens on the march

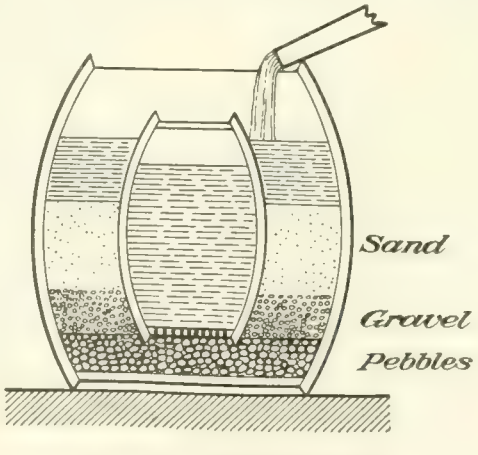


Fig. 3312.—Double Barrel Filter.

to keep their lips and throat moist. Water drinking is more or less a habit, which can be easily controlled. If practicable it is best to fill the canteeen with weak tea or coffee, every morning before leaving camp. Company commanders should supervise this very

important sanitary detail and make it possible for the men to get the tea or coffee. Both beverages are refreshing, allay thirst, and are mildly stimulating. Under ordinary circumstances a canteen of water, weak tea or coffee should last a soldier one day's march of eight hours. Alcohol and tobacco should be taboo on the march during the day. The use of chewing gum assists in keeping the mouth moist. Men who spend the night before drinking alcoholic beverages, smoking, and eating rich and highly spiced food may need more to quench an artificial thirst, as well as to wash out the toxins from the intestinal canal. For many reasons the soldier should confine his drinking to his canteen, because the water supply along the line of march is frequently polluted with ameba or typhoid infection. The Japanese escaped these diseases by drinking cold tea in the field during the Russo-Japanese war.

Fig. 3313.—Shelter Tent (Pitched).

Shelter for Troops in the Field.—The government has provided three kinds of tents for active service in the field and semi-permanent camps, namely, the shelter tent and the large and small pyramidal tents. In addition to the small and large pyramidal tents, which were adopted in 1911, the use of the common wall and conical tents will be continued until the supply is exhausted.

Each soldier carries as a part of his field equipment one-half of a shelter tent which also serves as a wrapper for his blanket roll. The two halves buttoned at the ridge form a complete tent. It is pitched on two three-jointed poles forty-seven inches long and occupies a space sixty-four inches deep and seventy-six inches wide. The infantry soldier in the field uses his rifle and bayonet instead of the jointed pole. The two triangular parts when pinned to the ground enclose an additional ground space twenty inches deep. A double shelter tent is formed by buttoning together the square ends of two single tents, two complete tents being used except one pole, with two guy ropes at each end. The shelter tent is used by enlisted men on the march or active field service of any kind when impracticable to transport ordinary tentage. With pole and pins one shelter tent weighs about nine pounds, and affords shelter for two men. (Fig. 3313.)

The large pyramidal tent, which is also intended for the enlisted men, has a roof sixteen feet square at the base and eighteen inches at the top, wall three feet high, height when pitched eleven feet. The eaves are two and one-half inches wide and the tabling at the bottom two and one-half inches wide. The body of the tent consists of the standard army drab cotton duck twelve and four-tenths ounces weight and will accommodate eight men. This tent is provided with a fly.

The small pyramidal which takes the place of the wall tent for officers, is nine feet square at the base and eighteen inches at the top. The wall is three feet nine inches high, and the height of tent to roof, when pitched, is eight feet. The eaves are two inches wide and the tabling at bottom two and one-half inches wide. This tent is made of standard army drab cotton duck twelve and four-tenths ounces weight and is intended for one or two officers. It is also provided with a fly. (Fig. 3314.)

The common or A tent provides shelter for three enlisted men and is six feet eleven inches long, six feet ten inches high and eight feet four inches wide, with a wall two feet high. The common tent with poles and pins weighs fifty-two pounds and has been frequently used during marches or in camps of maneuver.

There are two kinds of conical wall tents, the regulation and the improved. The regulation conical wall tent is round with a conical roof supported by one upright pole. It is sixteen and one-half feet in diameter and ten feet high, including the wall, which is three feet high. The truncated top roof forms an opening eighteen inches in diameter and is closed by a hood with hole in its apex for the spindle of the pole. The hood can be opened for the exit of smoke. The pole rests upon a strong iron folding tripod from which

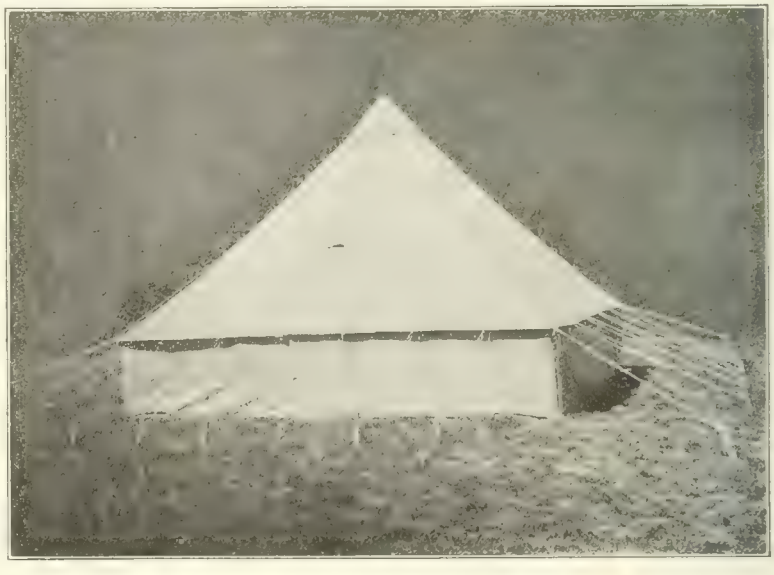


Fig. 3314.—Pyramidal Tent (Closed).

a camp kettle can be suspended. The regulation conical tent weighs with pole, tripod and pins 128 pounds and will accommodate eight cavalry men with horse equipment or twelve infantry men. It can be heated by a Sibley stove. The improved conical tent is especially intended for cold weather and is provided with stove and pipe.

Fig. 3315.—Hospital Tent (Tropical).

The wall tent, of which there are two models, the regulation and tropical, is principally intended for officers. The regulation wall tent has a ridge length of nine feet two inches, height when pitched eight and one-half feet, width eight feet one and one-half inches, with wall three and three-fourths feet high. It is provided with a round ventilator in front and stove pipe opening in rear for winter use. The tent and fly with poles weigh ninety-eight pounds. The tropical wall is slightly heavier and wider than the regulation wall.

Two kinds of hospital tents are issued at present, the regulation and tropical. The regulation hospital tent has a length of ridge pole fourteen feet three inches, height when pitched eleven feet, width fourteen and one-half feet and height of wall four and one-half feet. It requires one ridge, two upright and four eave poles, eighteen large double notched pins and twenty-six smaller pins. In each end is a circular ventilator and stove pipe opening. The regulation hospital tent weighs about 200 pounds complete and will accommodate cots for four or six patients. The hospital tropical tent which is an improvement on the Munson tent is larger than the regulation hospital tent and has an attic for ventilation. The hospital tent can also be heated by the Sibley stove issued by the Quartermaster Department.

In addition to regular tentage issued for the shelter of troops several portable barracks have been devised but have been little used in the United States Army. Among them may be mentioned the Ducker System which has been largely used in Germany. Improvised log huts have also been used during the winter months among troops during war where timber was abundant and afforded excellent shelter. (Fig. 3316.) Tents should be ditched as soon as practicable after pitching them in the event of rainy weather. Experienced soldiers never neglect this wise precaution which not infrequently saves them from wet bedding and flooded tent grounds.

Camp Site.—The health and comfort of the men is the first consideration in the selection of a camp site, after which should follow the questions of wood and water. The character of the soil is of the utmost importance and upon which the healthfulness of the men frequently depends. Dryness and porosity are of prime importance. The natural drainage is good when the surface sheds the rainfall into neighboring watercourses. On the contrary it is bad and the site insalubrious when it is level or has a level or slightly undulating clayey surface which retains the rainfall in pools. The vicinity of marshes and stagnant pools is undesirable on account of the annoyance and danger from mosquitos. Old camp sites are also dangerous and should be avoided. During hot or wintry weather protection by shade trees or timber is desirable.

Disposal of Waste.—*Human Excreta.*—The disposal of human excreta in camps and during active field service becomes one of the most important, as well as one of the most difficult problems the medical officer has to solve. Major Munson, one of our foremost army sanitarians says that "Either the excreta must be removed or destroyed, or the troops must be removed, or they will be destroyed." The night soil and urine in garrisons and permanent posts are disposed of as a rule by means of well installed sewer systems with modern traps and urinals, and will be dismissed without further discussion in this article. A few small posts still use earth closets or the Reed trough system.

Fig. 3316.—Log Hut (Canvas Roof).

In temporary camps where troops remain but one or two nights straddle trenches are used and each deposit individually covered with the fresh earth removed from the trench. Such trenches are located

with regard to the water supply, kitchens, and privacy, and all dug about one foot deep and wide enough for the men to straddle comfortably. Before abandoning camp they should be carefully covered, leveled with the ground and short stakes driven at each end to mark the spot in case other troops should encamp on the same grounds in the near future.

Should the camp be occupied for more than one or two days the pit should be dug five feet deep, three

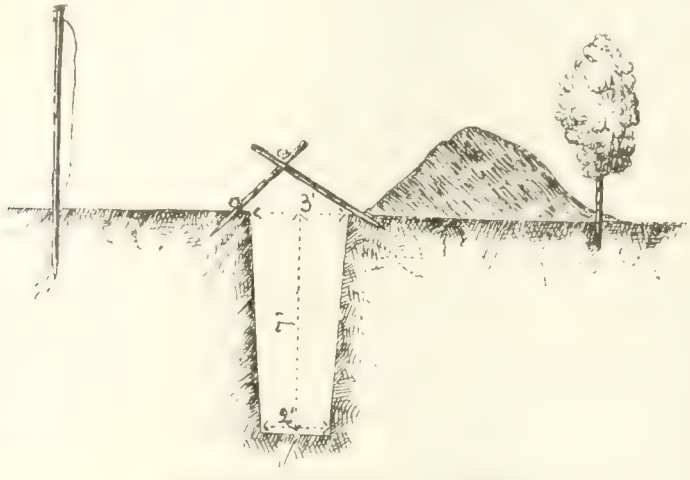


Fig. 3317. Construction of Pit Latrine.

feet wide at the top and two feet wide at the bottom. The earth should be carefully banked on the rear side and conveniently placed for covering the daily deposit. The length of sink ditching should accommodate from five to eight per cent. of the command at one time, two feet being allowed each individual. The latrine seat is made of a smooth straight pole resting on two forked sticks placed at intervals of six or eight feet along the pit. The back rest is also made of a straight pole or sapling lashed to the crossed stick in rear. Brush in front and in rear of the pit makes a good screen, in lieu of which tent flies may be used. Latrines should be dug as soon as troops arrive in camp and strict orders given at once to prevent defiling the camp site or polluting the water supply.

The disposal of the night soil and urine in permanent or semi-permanent camps requires more careful consideration. For several years after the Spanish War the Reed trough with pump and odorless excavator wagon was used and proved very satisfactory when properly operated. This system is impracticable for campaigning and besides will not do during freezing weather. The trough is fourteen feet long, twenty-two inches wide at the top, with sloping bottom fifteen inches deep at the upper end and eighteen inches at the lower end. There are eight hinged seats to each trough, the covers of which should fit tightly, to prevent the entrance of flies. The trough is filled four or five inches deep with a solution of milk of lime or water covered with crude petroleum. The water may be conducted into the trough by a pipe and faucet, or poured in by hand. Before removal by pump and excavator wagon the contents of the trough should be thoroughly mixed with a wooden paddle. The trough is protected by a knockdown shed on the inside of which is placed a tin trough for the urine, which is conducted into the trough at its lower end. The contents of trough should be removed at least one mile from the camp and carefully spread on the surface.

Destruction of the excreta would be ideal were it possible to devise an odorless incinerator. Among the devices for this purpose are the McCall, Conley, and Lewis and Kitchen all of which have been given a fair trial and possess merit. The principle of each device is practically the same, namely incinerator pans located over fire ovens, which are heated by means of ordinary cord wood. The installation of the McCall incinerators is more expensive than the other two mentioned because it has a combustion chamber lined with brick. The Conley incinerator has been highly recommended in some of the recent camps, especially on account of its ability to burn up kitchen garbage. The Lewis and Kitchen incinerators consist of a horizontal cylinder about ten feet long and three feet in diameter mounted on four wheels. The seats are placed on top, four on each side and reached by three steps. All of the above-mentioned incinerators are capable of excellent work, but are objectionable on account of the disagreeable odor developed during their operation.

Since 1910 attempts have been made in several of the large camps of maneuver to simplify camp sanitation and to adopt methods which might be available for war. In the large camps at American Lake, 1910, and San Antonio 1911, the simple pit system with an inexpensive box seat was adopted. Colonel Havard has devised a latrine box which is ten feet long, sixteen inches high, and three feet eight inches wide at the bottom, so as to cover safely the pit, which is three feet wide and six feet deep. (Fig. 3319.) The seat holes have hinged covers, which fit tightly, and the ground around the edges of the pit is leveled in order to prevent the entrance of flies. Once daily, usually about 9 A.M., the box is removed and the pit burned

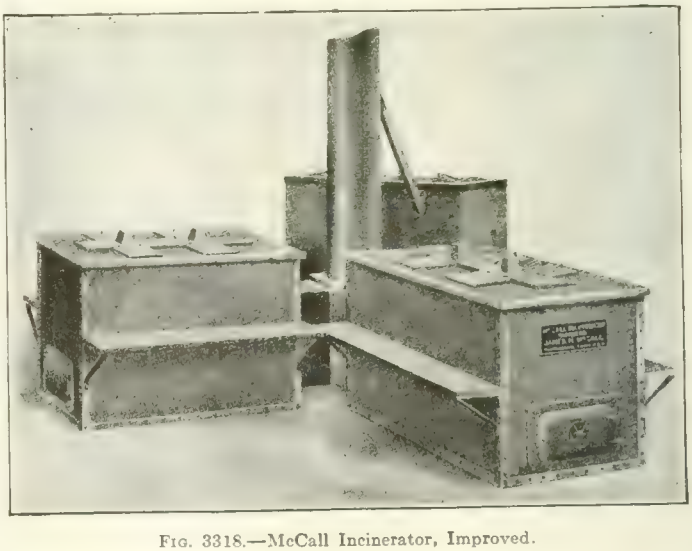


Fig. 3318.—McCall Incinerator, Improved.

out with hay and crude petroleum, after which the ashes and cinder are covered with quick lime, and the box replaced. About twenty pounds of straw or hay and one gallon of crude petroleum are required for each burning. Toilet paper should be provided for each latrine and kept in a covered box so that it may not be blown about the camp. Typhoid fever may be spread by infected closet paper.

Colonel Straub who was the sanitary officer at San

Antonio thinks these pits can be successfully burned out with the use of the crude petroleum alone. The interior of the boxes should be washed out daily with the milk of lime and the seats kept clean by daily scrubbing. With good soil and attention, such a pit should last two months. When filled within two feet of the surface new pits should be opened and the old ones closed. From experience it has been found that thirteen large ten-hole boxes and three small five-hole boxes are required for each regiment. Each latrine should be protected by a knock-down shed or brush

Fig. 3319.—Havard Latrine Box.

fence when possible. Galvanized iron urinals should be furnished for each pit or one improvised of ordinary lumber. The urinals should be kept covered with the crude oil and the latrines cared for by men especially detailed for the purpose. Frequent inspections should be made to see that the lids and lower edges of the box are fly proof. Night cans marked with red lanterns should be placed in the company streets and removed immediately after reveille.

Major D. R. Lucas of the 22d N. Y. Engineers has devised a portable straddle trench cover, which is less expensive and as sanitary as the Havard box when properly used. It consists of a platform with

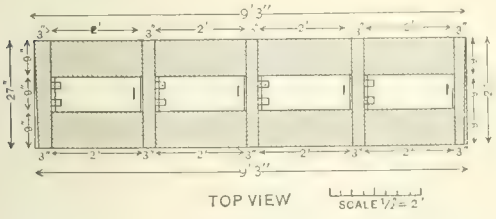


Fig. 3320.—Lucas Straddle Trench Cover. Top View.

hinged seats which fit closely when not in use. Each platform may accommodate from two to four men at a time. The platform consists of two planks nine inches wide held together by cross pieces which rest on the edge of the pit. The folding seats fit snugly between the side planks and cross pieces. These platforms when made of one inch pine lumber are light, and enough for a regiment can be transported in one wagon.

Garbage and Kitchen Waste.—The disposition of kitchen refuse in camp is a problem often fraught with serious difficulties. When possible it should be burned in kitchen incinerators improvised for the purpose. The old method of collecting the garbage in galvanized iron cans and hauling it away in sanitary garbage and refuse carts or wagons has been generally discontinued for the reason that the transfer from can to wagon and crematory frequently keeps the ground around the kitchen foul and not infrequently the company streets over which it is hauled. The older method of burying garbage is not to be thought of even for the most temporary camps if the ground is to be reoccupied within a short period. Such pits become breeding places for innumerable flies.

The company incinerator consists of a pit five feet long, two and one-half feet wide, sixteen inches deep at one end and twelve inches at the other. The excavated earth is banked around the pit and the bottom filled with stones on which a fire (which can also be used for cooking) is built. When the stones have become thoroughly heated the liquid is poured in gradually at the shallow end of the pit and the solid material placed on the fire. The company incinerator has been variously modified to meet the conditions of the soil. It was found an improvement in the San Antonio camp to build stone walls around three sides of the incinerator and pour the liquid upon the walls after they were heated, instead of on the lower side. About one-sixth cord of wood per day per company was sufficient to destroy the daily output of garbage and slops, from one company.

Major Arnold of the Pennsylvania National Guard has devised a garbage incinerator which has proved satisfactory among the troops of that State. A pit sixty inches long thirty inches wide and forty-eight inches deep at one end and thirty-six inches at the other is filled up loosely with stones a few inches above the ground level. The earth is well banked up around it to exclude surface water. The sides are built up about fifteen inches to support the grating of

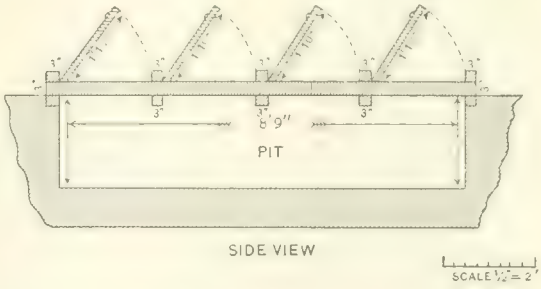


Fig. 3321.—Lucas Straddle Trench Cover and Pit. Side View.

cross bars which are provided to hold camp kettles, pots, etc. The fluids and solids are gradually burned each day. Colonel Straub states that the heat from the fire does not penetrate deeper than one foot of the bed rock and that deeper pits become foul and breed disagreeable odors when not used.

Captain Guthrie of the Engineer Corps has devised a nest of evaporating pans for the kitchen incinerators which he reports uses less fuel and gives better results. These pans were used in the Second Division Camp,

Texas City and were reported on favorably by the medical officers.

The Alamo incinerator devised by Captain Charles is highly commended and consists of a clay mound through which runs an ascending horse-shoe flue opening about three feet above the furnace below. The base of the Alamo incinerator rests on a bed of stones. The furnace and flue may be made of empty barrels, which ascend in the form of a half circle and is surrounded by wet clay which hardens with burning and becomes very durable. The furnace rests on the

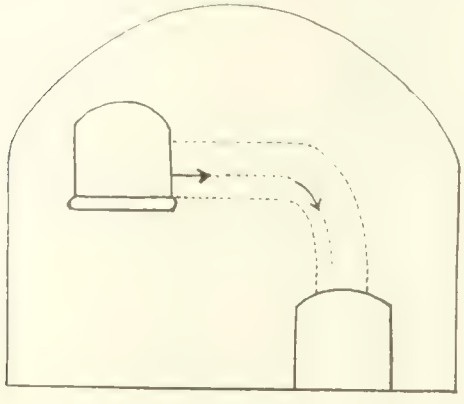


Fig. 3322.—Alamo Garbage Incinerator.

stone bed, and flue above ends on a platform into which the garbage is emptied. Officers who have used this system pronounce it an improvement on the regulation kitchen incinerator and that it requires less fuel. (Fig. 3322.)

Galvanized cans may be used successfully for the collection and disposal of kitchen garbage and slops if used in connection with the odorless excavator wagon. In order to carry out this system properly the solids should be separated from the fluid by means of a strainer which may be removed from can to can as they are filled. The excavator wagon sucks up the fluid without soiling the ground if carefully done and may be hauled to a distance. The solid material may be burned on the kitchen fire or carted away in wagons or sanitary carts. A platform twelve inches high and long enough to support two galvanized iron cans should be built in rear of each company kitchen when cans are used. The platform should be white-

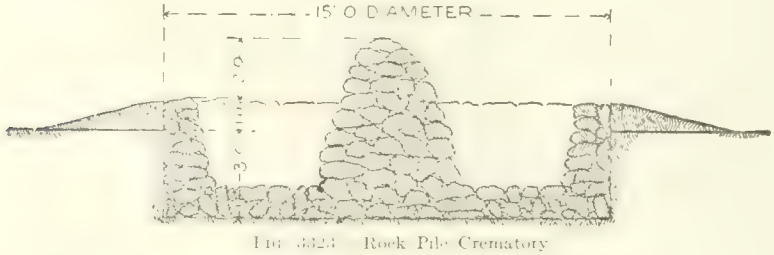


Fig. 3323.—Rock Pile Crematory.

washed every day or two during the encampment and the vicinity kept scrupulously clean.

Where the ground is sandy and porous the fluid element of the slops may be poured into six-inch post auger holes or pits provided with covers and seives to catch the solids which are easily consumed on the kitchen fires. The Rock-Pile Crematory has been found useful for the incineration of garbage, refuse, manure and liquids and is officially recognized by the Quartermaster Department. It consists of a circular pit fifteen feet in diameter, three feet deep and covered with loose stones to the depth of fifteen inches, around which is built a circular wall one foot above the ground line and filled in with earth to prevent surface water from gaining access to the pit. A pyramid of large stones, four or five feet high, occupies the center of the pit. This crematory has been used in our service repeatedly and given general satisfaction. (Fig. 3323.)

Manure.—The manure from picket lines and corrals should be raked up carefully each day and hauled several miles from camp and burned with the aid of crude oil. During hot weather the picket lines should be burned over at least weekly, using hay bedding and ten gallons of oil for each line. This serves to suppress odors as well as to prevent the breeding of flies. Burning the manure within the camp usually results in a smudge which produces a very disagreeable odor especially in hot weather.

Disinfection and Disinfectants.—Disinfectants are agencies which destroy the specific causes of infectious and contagious diseases, and have practically the same action as germicides, with which term they are synonymously used. Disinfection is therefore the destruction of pathogenic organisms before they gain entrance into the system. Antiseptics are substances which lower the vitality of microorganisms, so as to prevent their propagation, and hence the decomposition of organic matter. Deodorants are substances which correct or destroy disagreeable odors and mask foul smells from filth, which may foster diseases. With absolute cleanliness, deodorants are unnecessary to preserve health and should be discarded.

Sunshine and dry fresh air have great value as disinfectants and their use should be liberally employed by sanitarians. This action is more or less due to the actinic effect of the ultra-violet rays which have a strong restraining influence on the growth of bacteria and kills the most of them in time, especially the sporeless pathogenic variety. The bacilli of typhoid fever, cholera, and tuberculosis are particularly sensitive to sunlight. The bacilli of diphtheria thus exposed live only one or two hours and Koch states that the bacilli of tuberculosis can live but a few minutes in the rays of sunshine. The germs of typhoid fever and cholera are oxidized within two or three feet of the surface of water. The oxidizing influence of sunlight in water depending upon its clearness and depth.

Dry air is more valuable than moist atmosphere as a disinfectant, and hence buildings, tents, bedding and clothing should be aired and exposed during sunny dry weather when possible. Many pathogenic microorganisms are destroyed in the process of putrefaction by the hardier saprophytic forms. This principle has been employed in the destruction of pathogenic organisms and organic matter pertaining to human excreta. Dryness, sunlight, and cleanliness are the keynotes to sanitation.

Cleanliness is a very important factor in the work of disinfection especially washing and scrubbing, which not only removes bacteria but organic matter, the pabulum in which pathogenic organisms thrive. Experimentation has shown that the dilution and attenuation of bacteria safeguards health and that the system can take care of infection in minute and diluted amounts. Mr. Lawson Tait, the great English surgeon, depended on absolute cleanliness almost to the exclusion of disinfectants. Desiccation is also a very important factor in natural or artificial disinfection and sooner or later all microorganisms may be destroyed through this process.

Many methods of disinfection and sterilization are

employed by sanitarians for the prevention of infectious and contagious diseases besides sunshine and fresh air, among which may be mentioned heat, chemicals, and gases. Fire is a great purifier but its field of usefulness is limited on account of its injurious and destructive effects. Hence disinfection by the use of fire is usually limited to the disposal of human excreta, garbage, manure, sweepings, and the bodies of dead animals, except when disinfection is necessary to prevent the spread of malignant diseases and non-injurious disinfectants are unavailable. Dry heat continued at 150° C. for one hour will destroy all forms of life even the most resistant spores. Koch determined that dry heat at 117° C. would destroy only a few of the least resistant microorganisms but at 140° it would destroy them all, although it would scorch and ruin clothing at that degree. For this reason dry heat is practically useless for the disinfection of clothing, blankets, mattresses, etc.

Boiling is a very effective method of destroying infection of every kind and has become a common and everyday procedure for this purpose. Boiling at 60° C. for twenty minutes will destroy the microorganisms of cholera, typhoid fever, diphtheria, plague, tuberculosis, pneumonia, erysipelas, and practically all non-spore bearing bacteria. Boiling can be applied in the disinfection of underclothing, linen towels, bedding, and practically all kinds of linen and cotton fabrics. It can also be used for the disinfection of cups, dishes, pans, and kitchen utensils. One of the most satisfactory methods of disinfection is the application of steam or moist heat.

Many kinds of autoclaves and steam sterilizers have been devised for the disinfection of surgical instruments, dressings, infected clothing, bedding, etc. Arnold's and Boeckman's sterilizers have been largely used in Army hospitals for the disinfection of surgical instruments and sterilization of dressings, and have proven very satisfactory. Many of our large quarantine stations, hospitals, asylums, etc., are provided with expensive disinfecting outfits, generally consisting of the Kinyoun-Francis circular disinfecting chamber with the usual formaldehyde retort attachment. In cases of emergency in the field, a camp kettle may be used for the disinfection of instruments, etc., by laying them on sticks placed across the top of the kettle and covered with a towel or other cloth and bring the water to the boiling point. Koch found that superheated steam at a temperature of 110° C. would destroy the spores of anthrax in ten minutes.

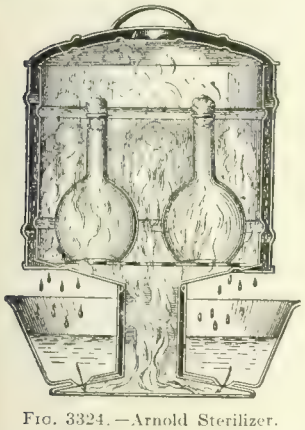


Fig. 3324.—Arnold Sterilizer.

Among the chemicals employed in solution bichloride of mercury is the most powerful and the most commonly used. A solution of 1 to 1,000 will destroy ordinary bacilli free from spores in a few minutes. The corrosive sublimate solution is used as a disinfectant for clothing, furniture, floors, walls, etc., but is not satisfactory for sputum or excreta because it coagulates albumen and thereby protects the inner bacilli from disinfection. This may be prevented by the addition of five parts of sulphuric, hydrochloric, or tartaric acid, or ten parts of common salt, for each part of the sublimate (Havard). Upon long exposure to air and sunlight sublimate solutions may undergo a change to calomel and therefore become unreliable.

Carbolic acid three to five per cent. gives general satisfaction and is largely used for the disinfection of sputum, excreta, etc. It may also be used for the disinfection of surgical instruments, clothing, leather and other fabrics. Tricresol which is also manufactured from coal tar is twice as powerful as carbolic acid. Reed states that a one per cent. solution of tricresol will destroy pus-producing organisms in half a minute. It may be used for the disinfection of sputum and excreta as it does not coagulate albumin as is the case with the sublimate solution. Equal parts of crude carbolic acid and concentrated sulphuric acid form a soluble compound which possesses superior germicidal powers to carbolic acid alone. Formaline which is a forty per cent. solution of formaldehyde in water is very valuable as a disinfectant and is generally used in a five per cent. solution. A ten per cent. solution renders fecal discharges, containing pathogenic bacteria, sterile within an hour, and tubercle bacilli are killed by a five per cent. solution within the same time.

Quicklime or calcium oxide may be used as a powder or solution for disinfecting purposes and possesses the qualities of efficiency and cheapness. It is a strong and reliable disinfectant and is largely used for the disinfection of latrines and grounds saturated with organic matter. Quicklime is especially valuable for sprinkling on latrines, urinals, company kitchen grounds, picket lines, laundries and lavatories. As milk of lime it has been used successfully in the Reed trough system for the disposal of human excreta. Milk of lime is made by mixing slaked lime with four to eight parts of water and white wash by adding more water. When exposed to the air for some time, quicklime is acted upon by carbon dioxide and becomes changed into a carbonate which is practically inert.

Chlorinated lime is one of the most powerful germicides we possess and has been largely used for the disinfection of sewerage and water. Freshly prepared chlorinated lime should have a slight odor of chlorine. It is used either in the form of a powder or solution. A solution containing six ounces of the powder to a gallon of water is largely used for disinfecting discharges and scrubbing floors. A convenient method of using chlorinated lime for the disinfection of drinking water is to add one gram of chlorinated lime containing approximately thirty-five per cent. of available chlorine to one liter of water. This should be mixed thoroughly and enough of the mixture added to the water in question to make one part of chlorinated lime to 200,000 parts of the water. Labarraque's solution, permanganate of potassa, creosote, cresol, antiformin, ferrous sulphate, sulphate of copper, and chloride of zinc have all been used as disinfectants and germicides.

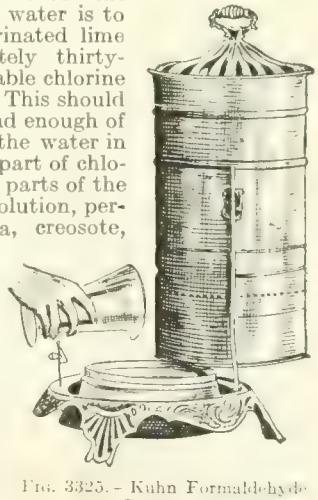


Fig. 3325.—Kuhn Formaldehyde Generator.

There are a number of gaseous disinfectants but the only two worth considering are formaldehyde gas and sulphur dioxide. Formaldehyde is one of the best known and the most powerful gaseous disinfectants we possess and besides is not injurious to cotton or woolen fabrics, rubber, leather, furs, colors and paintings. Among the many appliances devised for the generation of formaldehyde gas Kuhn's generator stands among the best.

Several methods for the employment of formaldehyde as a disinfectant are used but Roseman regards the potassium permanganate and formalin and the

formalin, lime, and aluminum sulphate the two best, because they do not require any special apparatus and besides evolve a large amount of gas in a short time. To use the permanganate formalin method 500 c.c. of formalin and 250 grains of permanganate of potassium are required for 1,000 cubic feet of air space. The permanganate is placed in a bucket or basin and the formalin poured upon it. Galvanized pails with flaring tops should be used to prevent the effervescence which is evolved from splashing over.

The formalin, lime, and aluminum-sulphate method requires for 1,000 cubic feet:

Solution A	Aluminum Sulphate	160 grams
	Dissolve in hot water	300 c.c.
Solution B	Formalin 40 per cent	600 c.c.
	And unslaked lime	2,000 c.c.

Mix solutions A and B and pour upon the lime. The lime should be freshly burned and broken in small pieces. A large bucket should be used. A few minutes after pouring in solutions A and B upon the lime it begins to slake thereby forming heat which drives off the gas.

Sulphur dioxide is one of the best and simplest methods of disinfection and simplest of operation. Five pounds of sulphur burned in an ordinary pot or Dutch oven will generate enough sulphur dioxide to disinfect 1,000 cubic feet. The pot holding the sulphur should be placed in a tub of water in order to furnish the moisture necessary to hydrate the sulphur dioxide upon which the disinfecting power of the gas depends. A small amount of alcohol should be poured on the sulphur in order to make it burn freely.

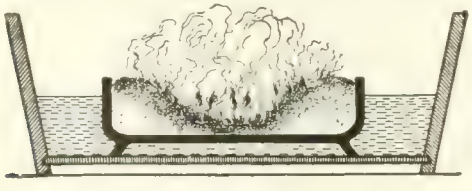


Fig. 3326.—Sulphur Burning Pan.

Major Munson of the Medical Corps of the Army has devised a simple but effective method for field disinfection. It consists of a copper or brass generator for mixing the permanganate and formalin and an impermeable gas bag which can be improvised in the field from ordinary rubber sheeting. A strip six feet long folded on itself makes a bag sufficiently capacious to hold the complete clothing, blankets and equipment of two soldiers, together with the disinfecting apparatus. The edges are pinned or stitched together and holes or cracks sealed with adhesive plaster. The soldier's poncho or an ordinary paper bag may be utilized.

Baths and Bathing.—As personal cleanliness is a material factor in health a tub, shower or sponge bath should be taken daily in warm weather and at least twice weekly during cold weather in addition to the regular daily ablutions, of hands and face. Each soldier should use his own soap and towel in order to escape skin affections which may be imparted through the use of a common towel and soap. Syphilis, gonorrheal ophthalmia, barber's itch, and other skin diseases of an infectious nature may be contracted in this way. Bathing is not only essential to cleanliness, but is necessary to keep the skin healthy by removing the semi-fluid greasy substance secreted from the sebaceous glands and dry perpsiration which clogs the pores. During the bath the skin should be rubbed with a coarse towel in order to stimulate the sebaceous glands as well as to remove the secretions.

For ordinary cleansing purposes the bath should be warm or tepid, from 80 to 95° F. If the bath is taken for bracing purposes, as is frequently the case during the summer months or in the tropics, the temperature should be lowered to 50 or 60°. For the general use of the soldier the shower bath is more sanitary and convenient than the tub bath. Various devices are resorted to in the field in lieu of tub or shower. An empty five gallon coal oil can with perforated bottom, elevated over one's head, makes an excellent shower with the assistance of a comrade to pour the water. In the tropics the natives secure the same result by pouring water over themselves with a bucket or dipper. The waste water from the bath should be removed by drainage and from the street lavatories by cans.

Care of the Bedding.—The soldier's bedding consists of a mattress of felted cotton, mattress cover, pillow, pillow cases, sheets, blankets and mosquito bars. For the field they are provided with bed and pillow sacks, which are to be filled with grass or hay. Gold medal folding cots are provided for permanent and semi-permanent camps, or when transportation is available. The mosquito bars are intended for field or garrison in order to protect the men against malarial or yellow fever mosquitoes. Boughs, cornstalks, loose straw, or hay, pine branches, or dry leaves make quite a satisfactory bed on the march or in temporary camps. Woven mats of native grass (patate) are largely used in the Philippine Islands both by the natives and soldiers in lieu of mattresses. The sheets and pillow slips should be washed at least once weekly. Mattresses should be aired twice weekly and the blankets every day the weather permitting.

Bedbugs.—Bedbugs are commonly found in the cracks and fissures of barracks, guard houses and old wooden buildings in which they can conceal themselves and propagate. They lay from fifty to sixty eggs which hatch within ten days and require seven weeks before maturity. Bedbugs are not only a great annoyance to the men in infested quarters but a menace to their health as well. While the rôle they play in disease is not definitely known at present, they are held responsible by different investigators for smallpox, typhus fever, tuberculosis, and leprosy. It is more than probable that, like the tick, flea, and mosquito, they are the host of some malignant protozoa, which cause serious disease, not yet definitely determined. They may find their way into the homes of the most respectable people and are not always a sign of careless housekeeping or uncleanliness.

Very considerable trouble is experienced in getting rid of bedbugs at times. The cracks in floors and around the baseboard should be filled up and waxed or painted. The cracks in walls should also be filled and walls and ceilings calsomined, painted, or repapered. The beds, mattresses, and bedding should be carefully examined and exposed to the sun. The insects will be found in the joints of the bed and around the seams and tufts of the mattresses. A number of agencies are used for destroying bedbugs in rooms or bedding which are badly infested. Gasoline, benzine, kerosene, and bichloride of mercury (1 to 1,000) are very effective, applied by brush or pouring. Scalding water is also effective and the fumes of sulphur dioxide, hydrocyanic acid gas or carbon bisulphide, when the floors and ceilings are infested.

Lice.—Three species of lice are found on man: (1) pediculus capitis, the head louse, pediculus vestimenti, the body louse, and the pediculus pubis or crab louse, which are found respectively in the head, on the clothing and in the short hair of the pubis, axilla or eyebrows. The eggs or nits are attached to the hair and hatch in about fifteen days. The blood-sucking habits of lice render them dangerous parasites, and no doubt they are capable of transmitting infectious disease to man. The body louse is supposed to be responsible for typhus fever. Lice may be passed

directly from one person to another and are often contracted from the beds of hotels or sleeping cars. They may be destroyed by kerosene, turpentine, carbolic acid one to fifty, bichloride of mercury solutions or tincture of the cocculus indicus. The hair should be cut short in badly infected heads. The clothing should be boiled, baked or steamed for body lice, and the pubis annointed with mercurial or white precipitate ointment for crab lice. A fine tooth comb wet in vinegar should be used to remove the nits.

Mosquitoes, Flies, Ticks, Etc.—Troops should be protected against mosquitoes, flies and other insects on account of their annoyance and powers of spreading disease. A number of diseases are transmitted by these insects notably among which are malarial fevers, yellow fever, typhoid fever, spotted fever, filariasis, etc. Troops should be required to use mosquito bars in malarial districts and head nets and gloves while on guard at night. Smudges are serviceable when camping in districts infested with mosquitoes. The larvæ of mosquitoes and flies should be destroyed when practicable by means of burning, petroleum and cleanliness. Screen kitchens and mess rooms are advisable in semi-permanent camps.

Spitting on Floors.—Spitting or expectorating on floors is not only a filthy habit, but a dangerous one as well, on account of the infection dried sputum may contain. Tuberculosis, diphtheria, pneumonia, and scarlet fever may be transmitted through expectoration or the secretions of the mouth. Dried sputum on floors, walls, furniture or bedding may contain live bacilli of tuberculosis for many months and become a menace to everyone who occupies such infected apartments. Strict regulations on spitting in public buildings have been published by the United States Government, as well as by many municipalities, railroads and street car systems with severe penalties for their violation. Soldiers should be instructed in regard to the dangers of miscellaneous spitting in quarters, especially its dangers from tuberculosis. Chewing tobacco is very objectionable for this reason, and should not be practised in quarters, or outside for that matter, as it is a filthy habit, which like snuffing, is rapidly disappearing. Orders forbidding spitting on the floors in quarters should become a barrack regulation and be rigidly enforced.

Stimulants.—*Alcoholic Beverages.*—All military writers denounce the use of alcohol among troops serving in the tropics, cold countries, or on the march, while many others regard it as harmful under all circumstances. Recently many practical experiments have been made with alcohol in marching, physical endurance, marksmanship, rapid firing, telegraphy, signaling and many other duties connected with the school of the soldier, in all of which better results have been secured from abstainers than drinkers, even in moderate quantities. The drinking soldier is also badly handicapped when attacked with pneumonia, erysipelas, influenza, typhoid fever, and other diseases of a microbic character because their resisting powers are lowered by alcohol.

Sickness among soldiers is more marked among the drinking element than among abstainers, especially venereal diseases and stomach and nervous troubles. More than ninety per cent. of the cases of insanity sent home from the Philippines, 1898–1904, was due to the use of alcohol. This was also true of many other diseases among men whose general health was impaired through its excessive use. Alcohol contributes neither to health, efficiency, discipline, or good morals and should be discarded among military men, especially when on active duty. Temperance should be encouraged among enlisted men and extra pay given abstaining soldiers as a reward for habits which lead to increased efficiency and improved health.

Coffee, Tea, and Cocoa.—Coffee, tea, and cocoa are mild stimulants, and in moderation are wholesome, agreeable, and refreshing beverages and grateful in conditions of mental and physical weakness. Used in excess both coffee and tea exert a harmful influence on the nervous system and the digestive tract and functions. Of the three coffee is the most commonly used in the Army, and is usually served at breakfast and the mid-day dinner. As a rule Army cooks prepare coffee very poorly, insisting that the men like it in large quantities and very weak. Besides they frequently use a portion of the old grounds in making fresh coffee and add the milk and sugar in the kitchen. Strong coffee should not be taken freely because it frequently causes nervousness, insomnia, functional disturbance of the heart and derangement of the digestive functions. Like tea, when taken in moderate quantities coffee cheers, refreshes, and relieves the sensation of fatigue and hunger. In diseases of the heart and arteries coffee is frequently interdicted on account of its stimulating effects.

Although the national beverage of the Russians, Chinese, and Japanese, tea is little used in the Army. In addition to the caffeine it also contains a considerable percentage of tannin which is liable to act as an astringent and cause constipation unless very carefully infused. Both cold coffee and cold tea are excellent beverages to relieve thirst on the march, and besides are much safer than the drinking water secured from springs and streams in the field. Cold coffee can be safely carried in the vessels or the tin canteen but cold tea attacks the metal and turns it dark. However, cold tea may be safely carried in the present aluminum canteen. Ordinarily coffee should only be issued the men at breakfast or while on guard at night. Tea or cocoa should be used at the remaining meals. Cocoa is not only a mild stimulant but is also a valuable food in condensed form. Chocolate is also an excellent article for the soldier and may be used either as food or drink.

Tobacco.—Although many intelligent men believe the moderate use of tobacco harmless, there can be no doubt of its injurious effects, inasmuch as with all beginners it causes dizziness, nausea and vomiting, pallor, cold clammy sweat, prostration, and confusion of ideas. With the majority of people, as the habit continues, the system becomes tolerant to a very marked degree. Many habitual users of tobacco suffer, however, from indigestion, heartburn, headache, respiratory and nervous disturbances, irregularity of the heart beat, sore throat, cough, hoarseness, and insomnia. There can be no doubt but that its excessive use causes blindness (amblyopia), cancer of the lips, tongue, and throat, and there are excellent medical authorities, who believe that heart disease, arteriosclerosis, and a susceptibility to tuberculosis result also from its continued use among certain individuals.

On account of its effects on respiration tobacco should not be used on the march, because it lessens marching endurance and dries up the secretions of the mouth. Smoking should not be permitted in dormitories or sleeping rooms on account of the carbon dioxide contained in the smoke. While the use of tobacco may be attractive to many men, especially among those whose opportunities in life are restricted, I believe its abstinence in the end would offset through increased health, all its temporary sensual pleasures. Smoking cigarettes and chewing are the most objectionable forms of its use, because the smoke of cigarettes is generally inhaled, and chewing results in the loss of saliva, which is so essential to mastication and the ensalivation of food.

Sexual Indulgence.—The exercise of the reproductive organs is not necessary to the health or well being of the individual. Many young men who enter the military service have been raised with the most liberal views regarding promiscuous sexual intercourse, in fact some have been taught that

sexual indulgence was actually necessary for the preservation of health and the development of the organs of reproduction. Dense ignorance, as a rule prevails among the youth of the country, of both sexes, regarding sex hygiene and other questions of habit, which so deeply concern their mental, moral and physical development.

The majority of our young men have never learned that clean living is the surest foundation of health, character and usefulness in life, and the highest moral obligations of mankind. Everyone should be taught that the sexual organs were intended for the reproduction of the race and not simply for the gratification of sensual pleasures. Besides they should know that in the functions of reproduction the testicles suppy a vital force and energy to the other organs of the body through a secretion which is of the utmost importance to life and character. Men who abstain from promiscuous sexual indulgence can better perform mental and physical work. This principle was recognized by Roman gladiators thousands of years ago and by the athletes of to-day.

Masturbation is occasionally practised by young men who have allowed licentious thoughts to dominate their will power. Masturbators are usually recognized by their solitary habits, loss of freshness, vigor, memory, will power and ability to concentrate thought. Emissions are common to most robust men and are nature's method of emptying the seminal vesicles at intervals of from ten days to two weeks. When emissions occur as a result of masturbation, gonorrheal inflammation, or sexual excesses they have another significance and require medical attention.

Mastication of the Food.—Whenever practical the hands should be thoroughly washed before eating not only for the sake of discipline and self-respect, but in order to prevent swallowing diseased germs. This is specially necessary during the presence of cholera and typhoid fever, and other diseases contracted through the mouth and intestinal canal. Food should be simple, nutritious and well prepared. Rich pastry and highly seasoned dishes should be excluded from the dietary because they excite the digestive glands to abnormal activity and finally produce indigestion, dyspepsia, and constipation. The food should be eaten slowly, adopting a modification of the Fletcher system, so that it enters the stomach well masticated and thoroughly mixed with the saliva, which in a measure digests its starchy components.

Well masticated and ensalivated food forms emulsified chyme in the stomach which is so necessary for the intestinal digestion and hence if the food is not thoroughly ground up in the mouth the stomach suffers in the end. Only moderate quantities of water or other fluid should be taken with the meals because they dilute the gastric juice, and make digestion more difficult. Food should not be eaten too hot or cold because extremes of temperature check the secretion of the gastric juice besides heat injuries the enamel of the teeth. To insure perfect digestion, complete mental and physical rest should be indulged in for at least one hour after eating in order that the blood may not be diverted from the stomach at this time. Meals should be eaten at regular intervals so as to accustom the stomach to pour out the gastric juice at the proper time.

Sleep and Rest.—Sleep and rest are nature's method of relieving mental and physical fatigue and restoring to the normal the process of metabolism. Sleep is therefore necessary in the vital processes of life and the prevention of physical and mental weakness, exhaustion and depression which are the precursors of disease. Individuals deprived of sleep on account of long hours, dissipation, or insomnia suffer a train of nervous disorders which frequently lead to serious consequences. Regularity in sleeping, eating, and recreation is absolutely necessary to insure normal health.

Men who turn night into day and spend the sleeping hours in drinking and sexual debauchery find out that they are burning the candle of life at both ends and soon develop into hopeless mental and physical wrecks. Experience has taught us that man should devote eight hours to sleep, eight hours to work and eight hours to meals, recreation and amusement during each twenty-four hours in order to maintain good health. During the sleeping hours one or more windows should be raised to insure ventilation and egress of the poisonous exhalations of the body (carbon dioxide).

Every soldier should be provided with two or more pairs of pajamas for use while in barracks. Sleeping in underclothing is an insanitary and vulgar habit; first because underclothing worn during the day are damp with perspiration and the semi-greasy fluid from the sebaceous glands, and second because they usually carry disagreeable odors. Soldiers should avoid sleeping on the bare ground while on the march or in camp on account of dampness. They should lie on the rubber poncho, or endeavor to extemporize an elevated bed of brush, hay, or weeds if not provided with gold medal cots or bed sacks.

Recreation and Amusement.—The recreation and amusement afforded the soldier have an important bearing on his health and efficiency, inasmuch as life frequently becomes monotonous and irksome in camp and garrison, especially during the "piping times of peace." This is especially true with young recruits and enlisted men, who are deprived of family life, home associations and loved ones. Medical officers and company officers should carefully watch those members of the command who exhibit early symptoms of low spirits and melancholy, which easily develop into serious and persistent nostalgia. These unfortunate mental conditions were of common occurrence among the volunteer and regular army troops on duty in the Philippines at the conclusions of the Insurrection, 1902, and necessitated the return of hundreds of them to the United States for recuperation.

There can be no question as to the serious effects of psychic influences on the general nutrition and health of the body, and the value of cheerfulness and contentment as a means of preserving health and efficiency among troops. Medical and company officers should regard the diversion and amusement of the men essential to their health and general welfare, as a part of their sanitary and military duties. The Government has erected in the majority of our military garrisons commodious exchange buildings which include the gymnasium, exchange, and club rooms. They are provided with rooms for billiards, pool, cards, library, kitchen, restaurant, besides the exchange room, gymnasium, and bowling alley. The gymnasium is equipped with modern appliances for exercise, besides a stage for plays, vaudevilles, concerts and a smooth hardwood floor large enough to entertain the entire command for dances and balls.

The exchange officer should study to make the post exchange an attractive club for the men when off duty, with provisions for the entertainment of the men's families and friends at least one evening during the week. The kitchen, café, and soda water counter should become important features of the exchange. Coffee, tea, milk, soda water with ice cream, orange and lemonade, and all kinds of soft drinks should be kept fresh and at minimum prices. The kitchen and lunch room should receive careful attention and a competent cook be employed.

The garrison should be provided with baseball grounds, tennis courts, and a golflinks where practicable, and the men encouraged to use them. Out-

door as well as indoor sports and games of all kinds should be encouraged and competitions between the different organizations encouraged. Hunting, fishing, and boating are useful, pleasant, and healthful recreations and are available at many army stations.

A well selected library with the popular dailies and magazines should be provided at every military post and the men encouraged to read them. The post school for the enlisted men should become an important feature in the life of the soldier, especially as many of them have been deprived of the advantages of an early education. Attendance at school should be required during the first enlistment, but subjects taught should not extend beyond the sixth or seventh grade of our public school system. Service in the Army could be popularized and the soldier made more contented through the organization of industrial education, in addition to the elementary branches. No doubt hundreds of the young soldiers would be glad to serve an enlistment provided they were taught some useful trade or occupation. Such schools might be established in a number of the regimental or larger posts and embrace typewriting, stenography, bookkeeping, and accounting, telegraphy including the wireless, electrical engineering, cooking and baking, blacksmithing, wheelwrighting, saddlery, plumbing, etc. The mental and moral influence of the Young Men's Christian Association has been of the greatest value to the young men of the army and it should be established in every Army post and camp. Besides it adds greatly to the pleasures and contentment of the men as a result of the moving picture and slide lecture features. Soldiers should be encouraged in attending divine services at posts where chaplains are stationed, or in city churches adjoining the post.

Fig. 3327.—Normal Foot and Foot Print.

Drinking is one of the most fertile sources of moral and physical demoralization and should be discouraged by every officer in the service, who has the interest of the enlisted men at heart. An "Army Temperance League" should be established at every post and the men encouraged to join. Directly or indirectly the use of alcoholic beverages causes more sickness, inefficiency, trouble, and discontent in the Army than any other factor.

Personal Hygiene and Cleanliness.—The success of military hygiene and camp sanitation, depend largely upon the intelligent cooperation of the enlisted men. Every recruit should be taught the importance of personal hygiene and cleanliness and how to take care of himself. He should be taught the importance of fresh air, especially during sleep, of rest and sleep, of pure drinking water, of exercise, of bathing and personal cleanliness, clean clothing, skin, teeth, hair and bowels. Every soldier not only owes it to himself, but to the government, to supervise and scrutinize all the details of his surroundings, environment, and daily habits of life, regardless of the hygienic supervision that may be undertaken by the military authorities.

Care of the Feet.—Sound feet are of the utmost importance to the soldier, especially to the infantryman. In order to preserve normal feet and keep them in good marching order properly fitting shoes should be issued to the men. The Munson shoe recently adopted for the Army appears to be suitable in every respect. The special advantages of this shoe lie in the width across the ball of the toe and the soft box, which allow the toes to spread without pressure or friction. Long marches are liable to cause chafing and soreness, especially on the first day, and it is at this time that the greatest care should be taken of the feet. Greasing the feet with fresh beef or mutton suet as well as applications of the German foot powder are wise provisions for men who suffer from tender feet. Besides they should be washed morning and evening, and if opportunity offers, one or twice during the day, and socks changed. The feet may be toughened by strong warm solutions of alum or common salt, to which alcohol may be added.

Fig. 3328.—Army Russet Shoe. Front and side views.

For sweating feet a four per cent. solution of formalin or a weak solution of permanganate of potassium will be found useful. The nails should be kept trimmed and the corns removed by careful cutting or scraping. The application of generous strips of lead plaster over excoriated or chafed surface serves an excellent purpose when men are lamed from these causes on the march. Blisters which are liable to form on the heel should be opened by a sterilized needle on the lower edge. After the fluid has oozed away the blister should be covered with adhesive plaster. Men suffering from tender or gouty feet should endeavor to keep them scrupulously clean, dry, and encased in clean, dry socks.

Care of the Teeth.—The teeth should be cleaned every morning and just before retiring with a stiff brush and some suitable dentifrice, tooth powder or soap. All the particles of meat or food should be

removed by a wooden toothpick or dental floss silk. The soldier should have his teeth examined twice yearly by the dental surgeon, tartar removed, and teeth placed in good condition. The mouth should also be rinsed out after each meal.

Underclothing and Bedding.—The clothing and bedding of the men should be regularly laundered and aired. Cleanliness of the underclothing is especially necessary on account of the poisonous excretions from the skin. Men should avoid sleeping in the underclothing by providing themselves with several suits of pajamas.

Care of the Bowels.—Although there is considerable variation in the frequency and regularity of the movement of the bowels among men who appear well and healthy, the general habit of mankind has fixed a daily morning movement as the most convenient and healthful. Some people feel a sense of discomfort unless they have two or three regular evacuations daily, while others have established the habit of going to stool every second, third, or fourth day, with no apparent discomfort or ill effects. Constipation therefore seems to be an interruption or irregularity in the established habits of each individual in this regard. While no one knows definitely the cause of constipation it is believed generally to result from lack of peristalsis or successive intestinal contraction which forces the contents of the intestines onward.

There are many causes of constipation, among which may be prominently mentioned neglect of nature's call, which is quite common among both men and women. Almost any one, who neglects the normal morning desire from time to time, is liable to contract an irregular habit which soon leads to constipation. Sedentary habits, lack of exercise, unsuitable diet, and heredity are given as permanent causes. When constipation becomes habitual it frequently produces a feeling of lassitude or debility, headache, mild vertigo, mental torpidity or low spirits, symptoms which are due to the absorption of toxic material from the intestinal canal. Constipation frequently affects the soldier's health and efficiency and should be corrected. Much can be accomplished through personal hygiene, diet, exercise and habit. Those affected with irregularities of the bowels should endeavor to establish a regular morning habit by going to the closet at a fixed morning hour whether they have the desire or not. Persistency in this rule frequently leads to success although it may take weeks or months. Many people suffer from constipation because they drink too little water. One or two glasses of hot or cold water before breakfast frequently leads to the morning movement.

The diet should consist of vegetable matter which leaves a large intestinal residue, such as cabbage, turnip, spinach, beets, corn, bran bread, or fruits such as apples, pears, peaches, prunes, cherries, either dried or fresh. Molasses is especially useful in regulating the bowels and is largely used among students, soldiers, and sailors. It is always better to establish normal movements from the bowels through a fixed habit, diet, or exercise. It becomes necessary at times, however, to resort to internal medicine. Among the simpler remedies are cascara, rhubarb, senna, phenophthalein, agar-agar, and the compound licorice powder. In chronic cases it is always best to consult the medical officer and continue treatment until the normal habit is reestablished.

Camp Diseases.—While there are no special diseases peculiar to the army alone, the conditions and circumstances of the soldier's life often make him more susceptible to certain maladies than men who follow the ordinary pursuits of civil life. Many of the diseases, which are common to camp life are contagious or infectious and consequently are preventable. This is also true of diseases which arise from insect and parasitic life. Exposure and climatic conditions are responsible for a large percentage of military diseases during active service or duty in the tropics, and immorality and intemperance for diseases of vice and alcoholism. It is gratifying to learn that both of the latter two evils are diminishing each year as a result of venereal prophylaxis and temperance propaganda.

The prevalence of certain diseases in army life depends largely upon climate, environment and local conditions. Malaria which heads the list of camp diseases in the Canal Zone is very rare at many of our northwestern posts. Venereal diseases, which are very prevalent among troops on the Mexican border, or near towns with a mixed population, are quite infrequent at posts in isolated sections of the country. Bacillary and amebic dysentery, which caused a very large percentage of the sickness among troops in the Philippines 1898–1904 rarely occur in the United States. This is also true of "dhobie itch," tropical ulcer, and other skin affections which are peculiar to tropical countries.

Acute Indigestion.—Stomach and intestinal disturbances are the common forms of sickness experienced by newly organized troops in camp, and is largely due to change and overindulgence in food. The greatest care should be observed in the preparation of the soldier's ration in the field and he should be required to live on it to the exclusion of the various articles of food and drink sold by the army of hucksters, who are frequently allowed to establish their booths in the vicinity of encampments. The presence of hucksters should be forbidden in the vicinity of troops, or, if permitted, their wares should be carefully examined by the sanitary inspector.

Acute Diarrhea.—Intestinal disorders including diarrhea, colic with nausea and vomiting commonly occur among troops during camps of maneuver or mobilization from dietetic causes and respond to treatment as a rule within a few days. Diarrhea not infrequently results from exposure, changes of temperature and water. Among volunteer troops this condition frequently results from the ingestion of foods and drinks purchased from camp vendors or poorly prepared rations, and is more or less preventable.

Constipation.—Conditions which disturb the habits of men, such as change from home life and food to camp life and the army ration frequently upsets the daily habits of men and causes acute constipation. The excitement of camp life, change of water and neglect of the morning call are also conducive to constipation. This condition frequently occurs among raw militia and should be carefully guarded against by the responsible officers.

Ptomaine Poisoning.—Toxins may form in foods as a result of bacterial action and seriously poison a command. The effects are violent gastrointestinal irritation with vomiting, purging, and extreme exhaustion. The change frequently occurs in hash or other foods kept over night in the pantry. Meats most liable to undergo this change are pork and veal. Milk is an excellent medium for bacteria. It is probable that the ptomaine tyrotoxicon, which is found in milk, cheese, and ice cream is due to bacterial action.

Alcoholism.—For many years previous to the Spanish war alcoholism held a prominent position among army diseases, averaging from thirty to sixty admissions per thousand annually. The rate has been reduced greatly since then, there being only sixteen admissions per thousand during the year of 1913. Alcohol is harmful as a beverage and should hold no place in the soldier's dietary because even in moderate quantities it reduces both health and efficiency. The moderate user of alcohol finds his marching endurance and accuracy in marksmanship reduced below that of the abstainer, besides

every mental and physical faculty is more or less disturbed. Drinking should be discouraged in every way among enlisted men and prohibited among commissioned officers, while on active duty, on account of its serious effects on efficiency and general health.

Malaria.—Malarial fevers headed the list of diseases in the United States Army for many years previous to 1898 and does so today in the Panama Canal and other localities, where the malarial mosquito abounds. The several types of this disease result from a malarial parasite which is introduced into the human system through the bite of the Anophelina.

Yellow fever is transmitted by the *Stegomyia fasciata* and filarial disease chiefly by the *Culex fatigans.* The parasite in malarial fever completes its cycle in twenty-four, forty-eight, and seventy-two hours and causes the quotidian, tertian, or quartan types of the disease. Besides the fever, which is known as intermittent, malaria frequently becomes an important factor in other diseases, such as diarrhea, pneumonia, and typhoid fever. Troops may avoid intermittent fever in malarial districts through prophylactic doses of quinine and use of gloves, headnets, and mosquito bars, although certain authorities believe the parasite transmissible through water. The smoke of burning insect powder will free a room of mosquitos. Quinine in five- or ten-grain doses three or four times daily usually destroys the parasites within the blood and body.

Bacillary Dysentery.—Although occurring in other parts of the world bacillary dysentery may be regarded as a tropical disease. It was very common among our troops serving in the Philippines, Cuba, and Porto Rico, and results from a specific microorganism, the *Bacillus dysenteriæ*, found in drinking water. The most favorable treatment consists of the administration of magnesium sulphate, 20 c.c. saturated solution every four hours followed by ten drops aromatic sulphuric acid. When hemorrhages, large sloughs, and offensive odors disappear and the stools are reduced to three or four daily the magnesia solution is given about twice during the day and the aromatic sulphuric acid proportionately. Bismuth subnitrate in sixty grain doses with three grains of salol is also given every six hours. Bacillary dysentery is a water-borne disease and is preventable.

Amebic Dysentery.—Amebic dysentery, an inflammatory disease of the colon, is caused by an ameba prevalent in tropical climates and is found in drinking water. The disease is characterized by frequent evacuations of mucous and bloody stools, tenesmus, irregular fever, ulceration of the intestinal mucosa, and not infrequently, hepatic abscess. The most successful treatment consists of one-third grain doses of emetine given hypodermically three times daily and continued for eight days after the disappearance of the ameba. Both forms of tropical dysentery may be prevented by sterilizing the water supply which contains the pathogenic agent.

Typhoid Fever.—Before the use of vaccination as a protective measure against typhoid fever it was one of the most prevalent diseases among soldiers during active campaigns or encampments. The specific organism is a short flagellated bacillus closely resembling the bacillus coli communis from which it is ordinarily difficult to distinguish. Typhoid bacilli abound in the feces and urine of patients affected with the disease, and is generally transmitted through drinking water into which they have found their way. They live and breed also in earth contaminated with organic matter but soon die when exposed to the sun. They may also live for several weeks in clothing and tentage and not infrequently become the focal center of epidemics in this way. Typhoid bacilli are killed in boiling water, or water at a temperature of 140° after fifteen minutes' exposure. They are also killed by solutions of carbolic and bichloride of mercury and other germicides. The infection is frequently spread through flies, food, and dust. Milk serves as an excellent medium for the transmission of typhoid infection and should be carefully examined during the presence of the disease. During the investigation of the disease it has been found that certain individuals are "carriers" of the bacilli who otherwise are in the enjoyment of normal health. As preventive measures suspected drinking water should be boiled and infected clothing and tentage disinfected. Soldiers under the age of forty-five should be protected by typhoid vaccination.

Parasites.—Intestinal parasites are very common among soldiers especially with men serving in the Philippines, where they are very prevalent among natives and animals. The common human varieties are the *Ascaris lumbricoides, Oxyuris vermicularis, Trichocephalus dispar, Dracunculus medinensis, Tenia saginata, Tenia solium,* and *T. bothriocephalus latus.* The eggs of the first four are discharged with the feces into springs and water courses and find their way into the intestines from drinking water. The *Dracunulus medinensis*, the guinea worm, is also believed to enter the system through the skin. The cystercerci of the saginata, solium, and latus enter the muscular flesh of the ox, swine, and fish respectively, from which they gain entrance into the human system through raw or partially cooked flesh. Trichiniasis, a very serious disease, is also contracted from eating raw or smoked hog flesh. *Bilharzia hematobia* may also enter the system from drinking water containing the urine of those affected with the disease. *Ankylostomum duodenale* is a common parasite among men who go bare foot and became very prevalent among American soldiers in the tropics. Filariasis is conveyed by the bite of [the *Culex fatigans* and possibly also by infected drinking water. Besides the above mentioned parasites there are a number of flukes or sucking worms which cause serious conditions in the Philippines. One variety invades the lungs and causes blood spitting and cough resembling consumption.

Skin Diseases.—These are prevalent among troops in the tropics, especially an eczematous form classified generally under the name of "dhobie itch." Many of [these eruptions are due to the *Tinea trichophytina* and are believed transferable by means of unboiled laundry. The favorite site for the eruption is under the arm-pits, between the groins and toes, although it may appear on any part of the body. Chrysarobin or an ointment composed of salicylic and benzoic acid is effective. An alcoholic saturated solution of salicylic acid destroys the fungus applied several times by means of a hair pencil.

Scabies.—Camp itch is not a common army disease during peace, but is not infrequent among troops during war. It is caused by a tiny insect the acarus or sarcoptes, which is an arachnid, belonging to the spider family. The mite can be seen with an ordinary watchmaker's glass. The disease is ordinarily communicated by means of infected bedding or clothing. The treatment consists of two or three applications of sulphur ointment on successive evenings before retiring. Boiling or disinfection of the bedding and clothing is necessary to prevent the spread of the disease.

Poison Ivy.—Many individuals are very susceptible to poisoning from the rhus toxicodendron or poison ivy, a small stubby plant found almost over the entire United States, and well known to every one. It is frequently found clinging to rocks and fences and differs from the Virginia creeper by having three leaflets instead of five. The disease is apt to appear on the hands and face, and on the genitals of those who expose themselves to the poison while at stool. The treatment consists of applications of alcohol and alkaline solutions, especially bicarbonate of soda.

Venereal Diseases.—Diseases of vice are usually classed among the diseases of camp on account of their prevalency and ease of contraction. They may

result from a single exposure and are generally associated with the use of alcoholic beverages, which are stimulants to the sexual desire. Besides the public women of a town or community, soldiers frequently contract venereal diseases from the dissolute servant class or loose women, who frequent dance halls and disreputable saloons and brothels in the vicinity of military camps and garrisons.

There are three distinct types of veneral disease which are known as chancroid, gonorrhea, and syphilis, the order in which they are named representing the scale of their gravity.

Chancroids.—The least injurious, appears from three to eight days in the form of numerous ulcers on the foreskin or head of the penis. The results following the sores are suppurating buboes in the groins, large sloughing ulcers which sometimes turn into gangrene and partially destroy the penis.

Gonorrhea sometimes as serious as syphilis, appears from three to eight days with itching, redness, and running from the penis, and not infrequently results in stricture, inflammation of the bladder and serious inflammation of the joints, known as gonorrheal rheumatism. Gonorrheal pus is very infectious and if transferred to the eye by accident is liable to cause gonorrheal ophthalmia and loss of the eye.

Syphilis appears as a small sore, usually on the head of the penis or foreskin from two to four weeks after contact and soon becomes a hard ulcer known as the chancre. This is followed by an eruption over the body, enlargements of the glands, sore throat, loss of the hair, inflammation of the eye and often loathsome ulcers, disease of the bones, tumors of the brain, paralysis, locomotor ataxia, and other nervous troubles.

In order to prevent venereal diseases military authorities require unmarried men who have exposed themselves while on pass or otherwise to report to the dispensary for disinfection. The treatment consists of a urethral injection of a ten per cent. argyrol solution, or three per cent. of protargol and application of a 33 per cent. calomel ointment to the genitalia. Several prophylactic packets and tubes have been devised for individual use containing calomel, phenol, and lard, which have proven satisfactory. The tube of the A and N Protection contains camphor, phenol, calomel, lanoline, and benzoated lard and has been officially adopted by the War Department. The contraction of venereal diseases and the loss of mental and physical stamina from promiscuous sexual indulgence are entirely unnecessary and rarely occur among that class of men who have the higher standards of life and understand the moral obligations of mankind.

Mumps and Measles.—Mumps and measles are of frequent occurrence among soldiers, especially among recruits and the infection can be usually traced to the post or depot from which they came. Neither disease is serious, *per se*, although they may lead to painful and serious complications. The incubation period of mumps is from fourteen to twenty-five days and measles from seven to twenty days. Men suffering from both diseases should be isolated and clothing disinfected.

Rheumatism and neuralgia are common affections among soldiers although they cannot be properly classed as camp diseases. Many of the serious cases of articular rheumatism which are contracted in the army are probably due to unrecognized gonorrheal infection. This mistake will not be so common in future on account of the recent gonorrheal reaction test.

Tonsillitis.—Acute tonsillitis is a common disease of garrison life and usually occurs during the winter and spring months, and is supposed to be communicated directly from one person to another. There are two forms of the disease, the simple catarrhal and follicular. Tonsillitis frequently occurs as mild endemics in permanent barracks and is supposed to result from overcrowding and poor ventilation. It rarely occurs in well-ventilated dormitories and in a manner may be regarded as a preventable disease.

Dengue.—Dengue, which is also known as break-bone fever frequently becomes endemic in garrison and camp life and causes much sickness. Break-bone fever has been attributed to a certain hemameba, which has not been definitely confirmed. In many regards dengue resembles influenza from which it is frequently difficult to differentiate. Preventive measures beyond leaving the vicinity where the disease is endemic are unknown. The treatment as a rule is palliative.

Influenza.—Influenza or La Grippe as it is commonly called is an acute affection which usually begins with coryza and presents the features of an acute catarrhal fever with more or less prostration and debility. It affects the mucous membrane of the respiratory tract from the nose to the air-cells of the lungs. It appears in four forms: (1) the respiratory; (2) the nervous; (3) the gastrointestinal; (4) the febrile form. It is supposed to result from a special organism, Pfeiffer's bacillus, which is present in the nasal and bronchial secretions. Cases should be isolated and the secretions disinfected.

Diphtheria.—Although diphtheria has no more relation to army than civil life it frequently attacks soldiers who have exposed themselves to the infection among families living outside of the garrison in which the disease exists. Quarantine is necessary in such cases and serum protection among the contacts. It is injected in relatively small doses among persons brought in contact with the disease.

Tuberculosis.—Tuberculosis frequently develops among young soldiers of two years' service or less and is believed to be due to constitutional tendencies and weakness. During service in the Philippines a number of cases occurred among our men which were traced to contact with infected natives or their houses. Cases should be quarantined as soon as discovered and sent to the General Hospital at Fort Bayard, New Mexico, or discharged from the service.

Cerebrospinal meningitis, may be regarded as a camp disease although no serious epidemics have occurred among our troops for many years. The disease results from a specific microorganism, but the manner of its transmission is not definitely known. It is a highly fatal disease and occurs occasionally among troops in crowded quarters. Patients suffering from the disease should be isolated at once and the quarters and clothing thoroughly disinfected.

Smallpox.—Smallpox rarely occurs among troops on account of systematic vaccinations practised in the army. Every recruit is vaccinated shortly after enlistment and as often thereafter as the medical officer deems necessary. Convalescents should be kept isolated until the skin is free from crusts. Infected clothing, bedding and tentage should be destroyed or thoroughly disinfected. On the appearance of smallpox the command should be examined and those vaccinated who are regarded as unprotected.

Cholera.—Cholera may become a serious army disease during an epidemic, as was the case during the great epidemic in the Philippines which began in 1902 and continued until 1910. It is due to a comma bacillus found in the stools of patients. It is usually propagated by means of infected drinking water and food, but is also carried by flies, clothing, cooking utensils, knives, forks, dishes, etc. During epidemics strict quarantine should be observed and the greatest care paid to drinking water, foods and personal cleanliness. The official period of detention is five days. A prophylactic inoculation introduced by Haffkine has given favorable results as a protection against the disease.

Bubonic plague, an acute infectious disease of great mortality, prevails in the tropics and frequently becomes a menace to troops serving in the Philippines. The disease results from a bacillus transmitted by

fleas from rats, squirrels, and other rodents which are also subject to the disease. Destruction of rodents becomes necessary during epidemics.

Sunstroke, heat stroke, and heat exhaustion are frequently experienced by troops on the march or active field service during hot and muggy weather. The patient should be removed to a shady place if possible and clothing loosened. Stimulation by means of strychnia, digitalis or aromatic ammonia is indicated when the skin becomes cold and temperature subnormal. Artificial respiration may also be necessary. Cold applications are indicated when the face is congested, skin hot and dry and the pulse full.

Drowning.—A patient at the point of death from asphyxia may be resuscitated by keeping up the movements of respiration and drawing out the tongue in order to keep the air passages clear. Two methods of artificial respiration are employed, Silvester's and Hall's, both of which possess special advantages. Officers and soldiers should be instructed in resuscitation from drowning during their first aid course. The movements should be continued at least one hour before abandoning all hope.

Malingering.—Cases of gross deception are not infrequently practised by enlisted men to escape unpleasant duty, or secure discharge from the service. The usual feigned diseases and conditions are muscular pain, rheumatism, neuralgia, stiffness in jonts, lameness, blindness, deafness, nocturnal enuresis, and various forms of fits. Atropine and eserine have been used to produce chronic dilatation or contraction of the pupil for this purpose. Young medical officers are frequently the victims of these attempts.

L. Mervin Maus.

Hygiene, Naval.—See *Naval Hygiene*.

Hygiene of Transportation.—See *Transportation*.

Hygroma.—The term "hygroma" has been applied to a variety of conditions involving cyst-like spaces filled with fluid, and widely different processes have been classified under the same head. It seems desirable to abandon the use of the word and to apply to the various conditions names more suggestive of their pathology. An increase in the amount of fluid in a tendon sheath leads to the formation of a cyst sometimes called hygroma. The term has been applied also to synovial bursæ distended with fluid.

Hygroma Congenitum (Cysticum) Colli.—This term has been applied to a form of lymphangioma of the neck. The admirable description by König ("Lehrbuch d. speciellen Chirurgie," 1893) has been largely drawn upon in the following account.

The tumor is present at birth. The surface is irregular and the tumor itself is lobulated. The lobules sometimes fluctuate, and at other times are very tense. The location is almost always in the submaxillary region. It may grow very rapidly and become very large. In this case it involves the entire anterior surface of the neck, extends to the face, and hangs over the clavicle and sternum upon the thoracic wall. Cystic lymphangiomata may also occur over the clavicle and on the dorsal surface of the neck. The ventral tumors may penetrate toward the pharynx, larynx, and esophagus, and disturb the functions of these organs. The skin over the tumors is usually thin and may be even translucent. The growth is very prominent, and the portions lying directly over the great vessels may pulsate.

The functional disturbances in many cases are not marked; in others pressure upon the organs of the neck leads to dysphagia and dyspnea and congestion of the vessels of the head. The patients may succumb to these symptoms, but this is not the rule. The prognosis is unfavorable, as the majority of the cases soon become cachectic and die. Operation usually hastens the fatal result.

The tumors occupy the subcutaneous and deep connective tissues, extending close to the vertebral column. They displace and may infiltrate organs, as do the malignant tumors. They are multilocular and consist of relatively thin connective-tissue walls which may be lined by endothelium. They are filled with a clear or yellowish liquid, which as a result of hemorrhage may become thick and chocolate colored. The larger cysts are usually superficial; the smaller ones lie more deeply in the tissues, even at the base of the skull, in the mediastinum, and about the trachea and esophagus.

In the tumors there occur spaces in the connective tissue of various forms which are not separated from the connective tissue by any special membrane. The larger spaces are rounded in form, or are divided into pockets by septa springing from the wall. They communicate with each other by larger or smaller openings.

It is probable that the spaces arise secondarily, because the smaller they are the more clearly defined are the communications. The smallest spaces consist of a system of vessels constricted at irregular intervals, or of a cavernous tissue whose lumina present an anastomosing system of channels. In either case the condition is continuous with a system of small anastomosing vessels whose lumina are cylindrical or cleft-like, and have the characteristic distribution of lymph vessels. The spaces and channels are lined by endothelium. The cystic spaces, then, consist of enlarged and distended lymph vessels, a view supported by Köster, von Winiwarter, Wegner, and others. It was formerly held by Rokitansky, Virchow, and Arnold that they originate from the connective tissue.

Perhaps most of the forms observed in adults originate in the same way. In these rare cases the tumor usually contains only a few cyst-like spaces and occurs near the trachea or in the region of the clavicle. It is possible that some of them originate from aberrant thyroids.

Just twenty years after the appearance of König's article, C. N. Dowd of New York, published a monographic study of hygroma cysticum colli (*Annals of Surgery*, July, 1913). He collected ninety-one cases in the neck and thirty-five in the axilla, while eleven are characterized as general. Only such cysts should be included as have an endothelial lining, which accounts for the remarkable power of these tumors for growth. They are multilocular in character. The older view of their inherent fatality, aggravated by the knife is by no means borne out by facts. In the axillary type recovery is the rule. This type has long been known but seems to have been ignored by König. As a rule, tumors of this region occur independently of any formation in the neck, and suggest the rarely observed inguinal hygroma. See also the section on Lymphangioma, under *Angioma*.

H. S. Steensland.
Edward Preble.

Hygrophila.—The herb, also the seeds, of *H. spinosa* T. And. (fam. *Acanthaceæ*), an annual or biennial plant of India, very largely used medicinally by the natives. The herb contains a crystallizable body which is probably alkaloidal; the seeds, considerable gum and much fixed oil, with indications of an alkaloid (*Hooper*). The drug acts as a diuretic and has been sparingly used as such in British practice. It has also been marketed as an adulterant of chiretta.

Henry H. Rusby.

Hymenolepis.—A genus of tape-worms, *Taeniidæ*; with small head, long neck, serrated proglottids, genital pores always on the left; three testes and eggs with three shells. Two species, *H. diminuta* and *H.*

nana, that are found in rats and mice may infect man through contaminated food. See *Cestoda*. A. S. P.

Hymenoptera.—An order of insects which includes bees, wasps, and ants. These animals are of medical interest on account of their poisonous stings. See *Insects, poisonous*. A. S. P.

Hymenostomata.—A division of holotricous infusorians in which the mouth is always open and provided with an undulating membrane. Most of these ciliates are free living. One genus, *Colpoda*, has been recorded in connection with dysentery. See *Protozoa*. A. S. P.

Hyoid Bone, Injuries of the.—Of the few cases on record of fracture of the hyoid bone, three were produced by hanging; three by the throat having been seized between the thumb and fingers; three by direct blows or falls upon the front of the neck; and one by muscular action alone.

In those cases in which the injury was produced by hanging, the body of the bone was broken. In all of the other examples the fracture involved one of the great cornua, or occurred at the junction of the cornua with the body. Crepitus is generally absent. In two of the recorded instances the adjacent mucous membrane of the pharynx was ruptured.

The symptoms observed have been a sudden sensation as if a bone had been broken; in a few instances a profuse bleeding from the fauces; difficulty in opening the mouth; in some cases dysphagia and aphonia; pain in movements of the tongue, with, usually, more or less swelling about the neck and ecchymosis; later, cough, expectoration, and hoarseness. Bleeding, or severe inflammation with edema, may render the situation serious and the swelling may encroach upon the larynx sufficiently to cause dyspnea. The circumstances which indicate with certainty the nature of the accident are unnatural mobility of the fragments, with or without crepitus, and an angular inward projection, which may generally be felt in a careful examination of the pharynx. The accident can be regarded as dangerous only in view of its complications. Of three cases in which it resulted from a direct blow only one survived, while of three resulting from lateral pressure upon the cornua all recovered.

The amount of difficulty in replacing the fragments of the bone will depend largely upon the extent of displacement and the consequent laceration of the neighboring tissues. An attempt should be made to accomplish replacement by introducing one finger into the mouth, while, with the opposite hand, the fragments are supported from without. In case of fracture of the cornu, should the displacement of the fragment be great, or if the cornu has penetrated the pharynx or become entangled in the tissues, attempt should be made to replace it. If this be found impossible the fragment may be removed. Edema of the glottis may demand intubation or even tracheotomy and dysphagia might call for the use of the esophageal tube. From the nature of the parts, any attempt at the application of a splint or support will be useless.

Rest to the parts, together with general measures to allay inflammation, will generally constitute the available treatment.

Luxation of the hyoid bone is a very rare accident. The principal symptoms noted have been pain at the seat of injury and difficulty in swallowing. In a case observed by Daly (*Archives of Laryngology*, vol. i., p. 162) luxation of the left cornu had been of frequent occurrence, caused usually by laughing or yawning. A laryngoscopic examination showed no internal lesion. Reduction was effected by grasping the throat firmly with the thumb and index-finger of one hand, steadying the head with the other hand, and then directing the patient to swallow vigorously, while at the same moment the parts were compressed between the thumb and finger, and then quickly released again. After the third effort the patient suddenly declared that he was relieved, and, in proof of this, he moved his head rapidly in all directions with ease and comfort, and drank successfully a glass of water.

D. Bryson Delavan.

Hyoscine, Scopolamine.—($C_{17}H_{21}NO_4$.) An alkaloid obtained from henbane and scopola, and existing in other Solanaceæ. It occurs as a thick, colorless syrup, soluble in alcohol, only slightly in water, but all its salts form in large, white, prismatic crystals, freely soluble in water, insoluble in alcohol and ether. The salts also resemble each other in therapeutic as well as physical properties. The hydrobromate, hydrochlorate, sulphate, and hydriodate are prepared, and the first-named is official.

As a mydriatic, it is rapid, energetic, and brief, but its action is readily maintained. During the administration of the drug its effect on the pupil is an early symptom. Dilatation is said to be more marked with a one-fourth to one-half-per-cent. solution than with a one-per-cent. solution of atropine; it has to be used with caution on account of the readiness with which the system is affected. In this direction, therefore, it is to be classed with atropine. For its effects upon the peripheral nervous system, and upon the secretions, the action of atropine may also be consulted. Centrally, however, its action is very different. The stimulant action so characteristic of atropine is here present, if at all, only as a very brief primary stage, and is followed by sedation, or depression, which constitutes the characteristic action of the drug. In very sensitive subjects the period of excitement may be prolonged, but usually it constitutes the slightest preliminary stage, and is followed by drowsiness, and if the dose be full, by a natural sleep. The spinal centers are similarly depressed, especially the reflexes. Depression of the sensory centers is very mild and does not materially affect painful conditions. Circulation and respiration are both reduced, though the pulse rate is increased.

Its toxic action is shown by the dilated pupil, rapid pulse, relaxed arteries and redness of the surface, dry, hot skin, rapid breathing, and coma and convulsions. Therapeutically, hyoscine has come into prominence as a sedative and hypnotic. It has largely supplanted morphine in the treatment of acute mania and delirium tremens, in restlessness, in the violent manifestations observed in all forms of mental disorders, and in hysteria and epilepsy. Its sedative action is very rapidly produced, and in the majority of cases a calm and refreshing sleep ensues. From this sleep the subject can be readily and completely roused. When pain is the cause of insomnia, the remedy is not of much service. Its action is purely calmative and sedative on the brain, and it should not be administered as a powerful or decided hypnotic. In insomnia it is applicable only in cases in which this arises from central or nervous excitement. In mania, and when there is much excitement, it should be given in full doses of gr. $\frac{1}{60}$ by the mouth, or gr. $\frac{1}{120}$ to $\frac{1}{100}$ hypodermically; a small dose is generally sufficient. When the symptoms are less acute, smaller doses should be given.

Hyoscine has also proved itself very efficient in the treatment of chronic mania and all nervous affections accompanied by mental restlessness; also in nervous diseases characterized by debility and tremors, as in paralysis agitans, disseminated sclerosis, and chronic alcoholism. In these cases the stimulating action of small doses is taken advantage of, and gr. $\frac{1}{200}$ daily or

twice a day is a sufficient dose. Its antispasmodic action is also secured with the same small dose, and it may be used, and with benefit, in chorea, asthma, and other spasmodic troubles of a nervous origin. The system readily becomes accustomed to it, and calls for increasing doses. When cardiac disease is present the use of hyoscine should be avoided or it should be given with great caution, on account of its depressing action on the heart and circulation.

The early physiological effects of the drug are manifested far in advance of dangerous symptoms, but in some cases very severe toxic symptoms have been produced by doses of gr. $\frac{1}{20}$ and $\frac{1}{10}$. Pilocarpine and morphine are physiological antidotes. The former has proved very serviceable and may be administered freely, as much as two grains having been required in a case of delirium tremens in which a comatose condition followed frequent doses of hyoscine. The official dose of the hydrobromide is gr. $\frac{1}{128}$ (0.0005).

HENRY H. RUSBY.

Hyoscyamine.—HYOSCYAMINA. ($C_{17}H_{23}NO_3$. An alkaloid obtained from henbane and also existing in other species of *Hyoscyamus*, and in belladonna, stramonium, and other *Salonaceæ*. Professor Ladenburg demonstrated that atropine, daturine, and duboisine are identical with hyoscyamine, both in chemical constitution and in physiological action. Any difference is to be found in the molecular arrangement of the constituents, and not in any fundamental change. The terms "atropine" and "hyoscyamine" have been applied to the heavy and light mydriatic alkaloids obtained from the belladonna and henbane plants, the former being the heavy and the latter the light alkaloid. It is now known that both the heavy and the light alkaloids may be obtained from either plant, according to the process of manufacture. The light may be converted into the heavy by melting under reduced pressure, by the addition of caustic soda to its alcoholic solution, and in other ways. It is of farther interest and importance that it is possible to obtain hyoscyamine in two forms, one of which is practically inactive, the other twice as active as atropine, and, by combining these two, to produce atropine.

Hyoscyamine occurs in light, silky, snow-white crystals, without odor, soluble in 120 parts of water, freely soluble in alcohol, and in acidulated water. There is also an uncrystallized or amorphous hyoscyamine, of a dark-brown extract-like mass, with a strong disagreeable odor. This appears to be a mixture of the various alkaloids and extractive matters. A sulphate, hydrochlorate, hydrobromate, and hydriodate of hyoscyamine are prepared, the first and third of which are official; they are alike in degree of strength and character, forming white, fine crystals very soluble in water. A sulphate and hydrobromate prepared from the amorphous alkaloid are amorphous, deliquescent salts, and less active and certain in their effects.

The therapeutic properties of hyoscyamine are very uncertain. At times it exactly resembles atropine, at others quite closely hyoscine. The cause of this variation is not determined, but it appears probable that it is due to the presence respectively of atropine and hyoscine in the commercial article, as such is the effect when these impurities are known to exist. The degree of activity is equally variable. It is normally weaker than both atropine and hyoscine, and is often so weak as to require doses which would be dangerous in the case of either of those alkaloids. On the other hand, alarmingly poisonous symptoms sometimes follow the ordinary dosage, which is larger than that of the others. The presence of the amorphous salts in the market is the source of much of the uncertainty of its action, and the cause of many of the toxic symptoms. The dose of these salts is usually much larger, being from $\frac{1}{4}$ to 1 grain, but they should never be employed.

The mydriatic action of hyoscyamine is rapid and powerful, but not so manageable as that of atropine. Cases are reported in which it produced spasms of the ciliary muscle and intense pain and distress; the solution used was gr. $\frac{1}{4}$ to the dram, and relief was obtained by placing in the eye a stronger solution of the same alkaloid. The toxic effects produced are the same as those of hyoscine, viz., dryness of the throat and mouth, and of the skin, accelerated pulse, dilated vessels, and excitement followed by convulsions and coma.

This alkaloid is employed as an hypnotic, nerve sedative, and antispasmodic, in mania, restlessness, delirium, insomnia, and all conditions accompanied by mental excitement; also in asthma, chorea, epilepsy, etc. The official dose of both the hydrobromide and the sulphate is gr. $\frac{1}{128}$ (0.0005).

HENRY H. RUSBY.

Hyoscyamus.—HENBANE. "The dried leaves and flowering tops of *Hyoscyamus niger* L. (fam. *Solanaceæ*) collected from plants of the second year's growth, and yielding when assayed by the following process, not less than 0.08 per cent. of mydriatic alkaloids." (U. S. P.)

This definition has been much criticised and its wisdom has been recently clearly disproven. It will doubtless be radically changed in the next edition of our Pharmacopœia.

Commercial supplies of henbane have represented three forms or stages of the plant's development. Normally, the plant produces a large fleshy root during the first year, from which it flowers, fruits and dies during its second. Frequently, it runs its entire course as an annual. The three forms of the drug are readily distinguishable. The first-year leaves of the biennial form are large and long stemmed and, of course, have neither flowers nor flowering stems attached. Those of the second year are relatively small, nearly stemless, and more or less associated with flowering and fruiting stems. These flowers are of a sulphur yellow and abundantly purple veined. The annual form, "seedlings" as they are often called in commerce, consists of small annual plants, often only two or three inches high, with slender roots attached, yet frequently bearing one or more flowers or fruits. These flowers are mostly devoid of purple veins. It has been assumed that only the second-named form is fully active, and on this assumption the above definition was based. Numerous assays made by the U. S. Dept. of Agriculture have shown that this difference does not exist. In most cases the seedlings have been found more active than the average official form. Also, first-year leaves of the biennial plant have been found of excellent quality and Belgian cultivated first-year leaves are now recognized as first class in every respect. All forms are therefore likely to be recognized in the forthcoming edition of the Pharmacopœia.

Henbane is a native of Europe and Western Asia, where it is a very common and abundant weed. It is also cultivated for medicinal purposes. Rarely it occurs as a weed in the United States. It is so eagerly attacked by the potato beetle that its production here is impossible, the use of insecticides upon it being of course prohibited. It looks somewhat like the stramonium, but is not so large and is even more coarse looking and more strongly viscid hairy. The habit of the inflorescence is shown in the accompanying illustration (Fig. 3329).

The following is the description of the drug:

Coarsely, roughly, and glandularly hairy throughout, except the corollas; larger leaves shortly and broadly petioled, fifteen to twenty-five centimeters (six to ten inches) long, and two-thirds as broad, the

upper becoming smaller and sessile; blades angularly ovate, acute, coarsely and angularly toothed or lobed, grayish-green or slightly yellowish-green; flowers in pseudo-racemes, short-pedicelled, the calyx cylindraceous, somewhat contracted above the ovary, unequally five-toothed, the teeth triangular, acute, the corolla campanulate, five-lobed, sulphur yellow, with deep purple veins; capsule a two-celled-pyxis; odor heavy, narcotic; taste bitter, somewhat acrid. From tobacco, henbane is distinguished by its incised leaves, from stramonium by its hairness, and from belladonna by both these characters.

Fig. 3529. Henbane, Plant and Fruit (about one-half natural size). Seed Enlarged. (Baillon.)

A full account of the composition and properties of henbane would constitute, to a great extent, a duplication of our account of belladonna. It may therefore be most profitably considered by comparing it with that drug.

The alkaloidal percentage of henbane is very much lower than that of belladonna. Frequently, it falls below the required one-twelfth of one per cent., though this is usually due to the abundance of earthy impurities, which is very apt to occur in this drug. The most of this alkaloid is *hyoscyamine*, separately treated. Whether any atropine is present, is disputed, but if so, the amount is unimportant. Atropine may readily form during manufacturing operations, by conversion of the hyoscyamine. The most important variation from belladonna is in the presence of a small amount of hyoscine or scopolamine, also separately considered, in its alphabetical order.

The general similarity of henbane to belladonna in properties and uses will readily be inferred from its composition; yet the slight characteristic differences stated are sufficient to establish noticeable differences in these directions. These differences may be stated generally by saying that henbane is more distinctly sedative than belladonna, and that this sedative action extends to the cerebral, motor, and sensory functions, though less so to the latter. The marked tendency to delirium resulting from the use of belladonna may be quite absent in that of henbane, or even the opposite effect can be induced.

Hence the distinct uses of henbane. It is scarcely employed in eye practice, though it produces very similar effects to those of atropine. If distinct cerebral-depressant effects are desired, it is better to give hyoscine itself, but when we wish the effects of belladonna, but desire to avoid its mental disturbances, henbane is chosen. Its commonest uses are intestinal and cystic, or renal. The former use is mostly in combination with purgatives which would otherwise be griping. At the same time that this unpleasant effect is averted, the henbane itself powerfully promotes peristalsis, and is therefore laxative, even excelling belladonna in this respect. The second-named use is as a sedative diuretic, relieving both painful and spasmodic conditions of the genito-urinary tract. Here again it is usually combined with other drugs, such local diuretics as buchu, kava, or oil of juniper. It is, however, often given alone in colic, cystitis, calculus, etc. It is commonly given in larger doses than belladonna. There are official an extract, the dose of which is gr. i. (0.065); a fluid extract, dose ♏ iii. (0.2); a fifteen-per-cent. tincture, dose ♏ xxx. (2.0).

Henbane Seeds, though unofficial are largely employed. They are light brown, broadly kidney-shaped, and flattened, 1 to 1.5 millimeters long and nearly as broad, and finely pitted. Thus they bear a close resemblance to stramonium seed, except in color and in their size, which is one-fourth to one-third as great. Their alkaloidal composition is about the same as of the herb, but they contain twenty-five per cent. of fixed oil, and a little resin. Since their percentage of alkaloid is a little greater, the dose of the seeds is about one-fourth or one-third smaller than that of the herb.

There are eleven species of hyoscyamus, and several of them, notably *H. album* L., have similar properties and uses to those of *H. niger*. HENRY H. RUSBY.

Hyperemia, Artificial, as a Therapeutic Agent. During recent years, August Bier has developed a method of treating a great variety of diseases by the production of localized hyperemia. The exact position of this therapy cannot be defined at the present time, but in view of the fact that it has proven very useful and effective in the hands of a great many physicians and surgeons, it seems destined to play an important part in the treatment of many diseases. As with most new agents, hyperemia produced by the technique elaborated by Bier has been extolled by some in a most exaggerated manner and it will undoubtedly require years of patient study and observation before the proper place is allotted to this useful therapeutic agent. Exaggeration and overenthusiasm work injury and are sure to delay the general adoption of Bier's methods. Indiscriminate application of this therapeutic agent also works injuriously in the same way. An attitude of scientific reserve and careful investigation should be pursued, and finally all will clearly see the advantages and the disadvantages as well as the limitations of artificially produced hyperemia. At the present time one can already say with considerable definiteness what this agent can effect in a great variety of pathological conditions, but in the realm of severe acute inflammatory diseases a scientific scepticism must be maintained until the *post hoc* developments are absolutely and irrefutably proven to be *propter hoc*.

"Every working, functioning organ is hyperemic while doing its work." "All growth and regeneration are accompanied by local hyperemia, which is all the more marked the more active and energetic the growth." "All body reactions to foreign materials, in the broadest sense, are accompanied by hyperemia" (Bier). Hyperemia is therefore the most common agent that Nature avails herself of, in both normal and diseased conditions. In following the example of Nature, Bier has developed a new therapeutic field as well as a more modern conception of many pathological conditions.

During recent years the medical world has gradually faced about on the question of inflammation so that nowadays this process is recognized as something useful and reparative. Bier has emphasized this more than any other writer, and upon this he has based much of his work with hyperemia. The practical application of the pathologist's views above mentioned we owe to Bier, who says, Away with antiphlogistic measures, and let us assist Nature and increase the body's response, *i.e.* the inflammation.

In producing localized hyperemia one must keep the two types of hyperemia separate, as their therapeutic usefulness is very different. *Active* or *arterial hyperemia* is regularly seen after removal of an Esmarch bandage which has been used to produce ischemia. The part rapidly becomes bright red after removing the bandage. The same type is produced by active use of our muscles, by massage, and by the use of electricity. Chemical and thermic irritants produce this arterial hyperemia very readily, and the latter is particularly useful as a therapeutic means of producing this type of hyperemia.

Opposed to this is the more subtle type of hyperemia, the *passive* or *venous*. This is most readily produced by constriction of the return circulation, which naturally produces a venous engorgement of the distal parts. On removing the constricting bandage a more or less marked active or arterial hyperemia sets in, and takes the place of the previous venous hyperemia. Another practical method of producing this hyperemia is by the use of dry cups. Here, as in the constriction hyperemia, the venous hyperemia may not be the only type produced. Just as arterial follows venous hyperemia when a constricting bandage is used, so under the cups there may be a combination of the two types of hyperemia. This point is still unsettled.

It is of great interest to note that Bier originally began to use artificial localized hyperemia in the treatment of surgical tuberculosis in the early nineties of the last century. His attention was drawn to the possibilities of this treatment by the following observations, then generally accepted:

1. That the lungs were regularly the seat of tuberculosis, if the blood supply was deficient, *e.g.* in pulmonary stenosis the patients with great regularity died of tuberculosis of the lungs.

2. That, in acquired heart disease leading to pulmonary congestion, active tuberculosis rarely was found in the lungs. If venous congestion effected so much in the pulmonary circuit, Bier reasoned that a similar condition in the systemic circulation would probably lead to an equally beneficent result. This stimulated him to apply the constricting bandage in tuberculosis of bones and of joints; this marks the origin of his work with venous hyperemia. It is evident that the above reasoning is not faultless, as it is scarcely probable that the blood in the pulmonary circuit is venous in character, except in the larger vessels close to the heart. In the capillaries the blood rapidly becomes arterialized, so that the diseased areas are bathed in arterial rather than venous blood. Despite the fact that Bier's superstructure was thus erected on a faulty deduction, it will be evident in the succeeding pages that it promises much as a therapeutic agent.

In general Bier ascribed the following activities to hyperemia: (*a*) It diminishes pain; (*b*) it is bactericidal and works as a diluent; (*c*) it hastens resorption and assists in absorption; (*d*) it aids nutrition; (*e*) it acts mechanically in effecting good drainage.

(*a*) There is no doubt that hyperemia has a marked effect on pain, though for reasons still unclear it occasionally fails to diminish it. It is thought that the edema resulting from the production of artificial hyperemia works much as Schleich's infiltration anesthesia. At the same time the edema dilutes the concentrated and irritating exudates which surround the nerve filaments. Bier has called attention to the fact that in periostitis of the jaw, the pain ceases as soon as the cheek swells, and fractures in an extremity cause no pain when the limb becomes swollen. In these observations, that as soon as marked swelling develops, pain diminishes, I do not believe all surgeons will agree. Since my attention was first drawn to this contention some years ago, I have noted the point carefully and failed to convince myself of its accuracy. Still there is no denying the fact that a properly applied bandage producing constriction hyperemia will very frequently diminish pain. Both arterial and venous hyperemia act in this way.

(*b*) Hyperemia increases the local bactericidal powers and dilutes localized poisons. The latter action is the more readily understood. It is well known that what would be a fatal dose of a poison in a concentrated solution, can be given in a much diluted solution without a fatal result. The edema engendered by the constriction of a limb dilutes the toxins in just this way, while at the same time the same fluids are acting as bactericidal solutions. Colley's experiments go to show that the edema produced in an infected limb is much more bactericidal than that produced in the same way in a non-infected limb. This property of the serum is due to a great variety of factors. Hamburger has called attention to the fact that edema fluid is more bactericidal than the circulating blood plasma, and he ascribes this in part to the increased CO_2 and alkali content. It has also been shown that hyperemia produces a local increase in leucocytes, and Heile's work demonstrating an increased excretion of purin bases can be best explained by a rapid breaking down of large numbers of leucocytes. On the other hand, Joseph and Schwartzman have maintained that there are very few leucocytes in the edema fluid. (Joseph, Lehrbuch d. Hyperämiebehandlung, 1911.) It has also been shown that the use of the constricting bandage raises the local opsonic index. There can be no doubt as to this bactericidal effect of constriction hyperemia, though whether all bacteria are affected equally is doubtful. Clinical experience bears out the experimental work done up to date. How much of the bactericidal and of the diluent effects is produced by the incomplete stasis in the veins and how much by the same condition in the lymph circulation, future investigation will perhaps demonstrate. In the past the effect of constriction in the lymph circulation, which surely is affected first of all after the bandage is applied, has been almost entirely ignored. My clinical experience forces me to consider this an important element, especially in the production of the local edema and in the marshalling of the forces that develop in this bactericidal fluid. In 1912 Gelinsky, in studying this question, came to a similar conclusion. In fact he believes (*Zentralblatt f. Chirurgie*, 1912) that in acute inflammations the best results are obtained if only the lymphatics are compressed, producing edema without marked congestive symptoms. Venous hyperemia is particularly useful in combating the bacterial invasions and is therefore used instead of arterial hyperemia in localized infectious processes.

(*c*) The clinical fact that hyperemia aids in the absorption of fluids and soluble matter, whether these be within the body or upon its mucous surfaces, was accepted long ago. Klapp has shown by experiment,

very recently, that arterial hyperemia hastens quite markedly the absorption of injected lactose. On the other hand, venous hyperemia, so long as the bandage remains in place, diminishes local absorption. On removal of the bandage, absorption increases markedly. Bier doubts whether this secondary effect takes place if the constricting bandage is in place for many hours, and consequently employs massage to aid absorption.

Though venous hyperemia is not capable of accelerating absorption of fluids and of soluble substances, still it does seem to have a distinct absorptive action on certain pathological lesions. Bier refers to cases in which this form of hyperemia has led to the absorption of thickenings in and about joints, of thickenings in tendons, of keloids, etc. In this particular realm it is wise to reserve judgment until better evidence is at hand. Though we cannot deny that in acute or chronic suppurative processes all sorts of tissues melt away as a result of the disease, still in Bier's therapy we do not reproduce the condition of acute or of chronic inflammation, but only one symptom of this process. Dissolution of tissues in inflammatory conditions is probably due to some obscure activity, perhaps fermentative or autolytic, and as yet the proof is lacking that simple constriction of a limb leads to these activities.

Despite these theoretical conditions one cannot deny that stiff joints inprove under arterial and venous hyperemia. The explanation of the process is by no means simple.

(*d*) Another activity or property ascribed to hyperemia is the nutritional. Bier bases this claim upon a great variety of clinical data which are best read in his monograph. Regeneration of tissue is most active in inflamed areas, in fact it is usually excessive, and, as Bier believes, here venous hyperemia dominates the field. In the growth of the fetus a well-marked venous engorgement (*hyperemia*) prevails in the placental channels. In patients suffering from femoral vein thrombosis one frequently sees well-marked thickening of the extremity which possibly is in part due to a local hypertrophy resulting from venous obstruction. That this thickening is not due to deep edema alone, I feel sure from a case of bilateral femoral thrombosis that I have watched for a matter of a dozen years since the thrombosis developed. The observation that the epidermis becomes thickened and hairs increase in number near chronic ulcers points to a distinct nutritional effect. Arterial hyperemia also exerts a nutritional effect in the epidermis, according to Bier. On the other hand, chronic congestion of the viscera does not lead to increase of the connective tissue or hyperplasia of the parenchyma with any regularity. The latter result is unknown, whereas increase of the connective-tissue stroma is a moderately frequent result. While hyperemia appears to have no nutritional effect on the viscera, in the sense of leading to excessive growth and increased size of the parenchyma, Bier claims that it has some such effect on bones and connective tissue as well as upon the epidermis. Most of the data which Bier has gathered to prop this contention are scarcely sufficiently cogent to settle this particular point as to the nutritional effects of venous hyperemia, and until we obtain more data based on more modern and accurate work than that referred to by Bier, here again it will be well to reserve judgment. On the other hand, arterial hyperemia probably does make for a more healthy nutrition. For there can be no doubt that improvement in the peripheral circulation will frequently lead to a healing of ulcers or abort a threatened gangrene in diabetics or in old arteriosclerotic patients.

Until exact experimental evidence is produced showing that a constriction bandage will actually and regularly lead to increase in growth of the tissues in a limb, and until patients with chronic localized cyanosis show some changes due to forced nutrition, it is absolutely necessary to exercise all our scientific scepticism as to the nutritional value of venous hyperemia.

(*e*) To any one who has employed either constriction hyperemia or suction hyperemia it is surely evident that a mechanical irrigation of the diseased areas must regularly occur. In using the suction cup over an incised abscess, the most perfect and complete drainage is induced. The pus and débris are rapidly withdrawn and, after the cavity has been drained of these, bloody serum pours into the cup. The latter acts as an antiseptic solution and washes out every nook and corner of the infected cavity. In addition to this distinctly mechanical effect the adjacent tissues under the cup become edematous and hyperemic. On the other hand, the constriction bandage above an inflammatory area which has been incised leads to an identical result. It produces an edema, and this fluid is poured out copiously through the incision, thus thoroughly irrigating the diseased tissues from within. This constant flow from within outward washes out all the pus and débris and thoroughly disinfects the involved areas. A more ideal method of irrigation is inconceivable, and though I would not attribute the good results of Bier's method to this factor alone, as some are inclined to do, still I do feel confident that this peculiar activity is one of the most important and beneficent of those exerted by artificially induced venous hyperemia. That it would be an exaggeration to say that this is the sole beneficent activity of hyperemia will be self-evident to any one who has treated non-incised cases and effected a cure without making use of these mechanical principles that make for perfect drainage.

This most evident activity Bier has not emphasized as much as it deserves, which probably explains the zeal with which some have seized upon this as *the* important process underlying artificially induced venous hyperemia.

Technique of Application.—*Arterial hyperemia* is produced by the use of heat, in the form either of hot air or of hot applications. As both methods are well known to the profession, this phase of the subject can be treated briefly. Bier has employed the skill of Eschbaum, a local instrument maker, to perfect a great variety of hot-air boxes which are so

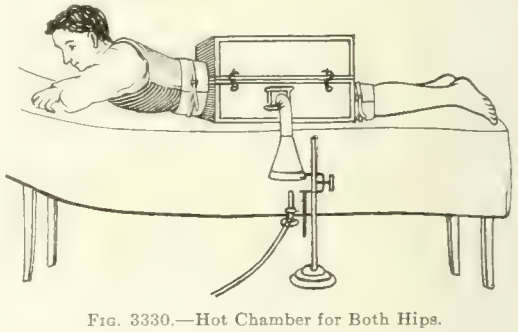


Fig. 3330.—Hot Chamber for Both Hips.

modelled that they fit on most of the surfaces of the body. (See Figs. 3330 and 3331.) Large boxes with vertical slits have been constructed to permit of hot-air applications to the spinal column. Other boxes have been made so as to encompass the pelvis and both hip joints. Smaller boxes are on the market for applications to the extremities. The openings in these boxes are lined with heavy material which prevents undue escape of the heated air. A similar result can be obtained by surrounding the parts of the body that lie in the openings of the box with heavy felt. The air is heated before entering the box by means of a gas or alcohol flame which is placed below the funnel tube that connects with the interior of the box. A

thermometer, so placed within the box that it can be read without opening the same, will aid in controlling the temperature to which the exposed part is subjected. Marked active hyperemia develops between 80°–120° C. (176°–248° F.). Though many prefer to surround the exposed part with cotton or flannel, Bier, despite the fact that he admits that this diminishes the danger of burning the patient, has given it up. He thinks these enveloping materials become

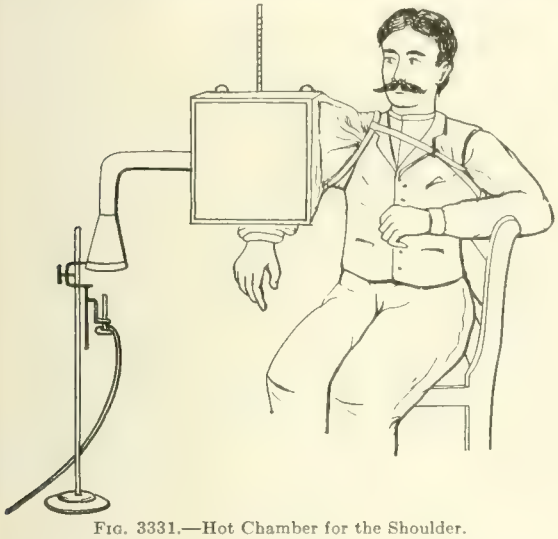


Fig. 3331.—Hot Chamber for the Shoulder.

moist and thus prevent a marked arterial hyperemia. It is wise, however, to place pieces of flannel between opposed skin surfaces so that no burns occur.

To obtain a more localized action and where these hot-air boxes cannot be applied, *e.g.* the face, a great variety of hot-air douches are used. Bier employs for this purpose a simple machine (Fig. 3332) which is so protected that it can be moved about, permitting the operator or patient to throw the stream of hot air

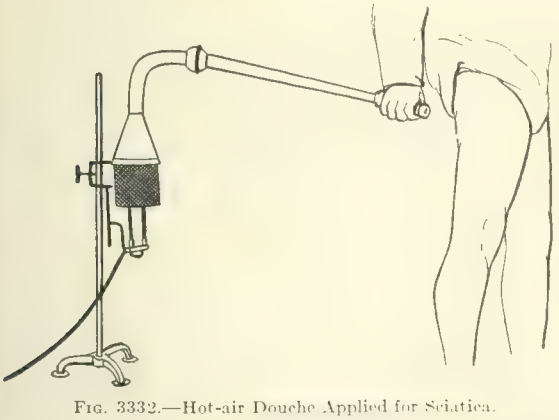


Fig. 3332.—Hot-air Douche Applied for Sciatica.

in different directions. This instrument resembles the chimney of his hot-air boxes and is well shown in the accompanying figures together with several of his hot-air boxes.

Much difference of opinion as to the duration of each treatment prevails. In some cases short applications (of ten minutes) are indicated, in others longer applications up to an hour or an hour and a quarter might be more useful. In general short treatments are used where there is danger of gangrene or where many joints are treated each day. Longer treatments are used in chronic conditions, such as rheumatic joints.

The use of hot fomentations is so general that it need not be entered into here. They produce hyperemia just as hot air does and by virtue of this action accomplish much that is beneficial.

To produce venous hyperemia, for most cases a less expensive armamentarium will suffice. The de-

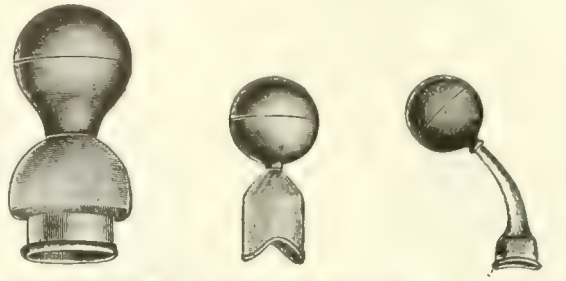


Fig. 3333.—Glass Cups for Suction Hyperemia. Other shapes are shown in Figs. 3334–3338.

velopment of part of this field is due to the ingenuity of Klapp, who deserved great credit for his important work along the lines of suction hyperemia.

Suction Hyperemia is induced by the aid of a variety of glass cups (Figs. 3333–3338) which are of various shapes and sizes, permitting their ready application to different surfaces. The smaller cups are fitted with hand bulbs, whereas the larger cups require a hand

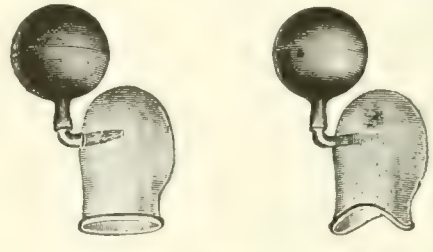


Fig. 3334.

pump to produce the necessary rarefaction within the cup. In the treatment of most cases the smaller cups are perfectly adequate, but in the treatment of more extensive inflammatory foci very large cups are required (Fig. 3338). Especially large cups are made for treatment of inflammatory conditions of the breast and hand. In cases of stiff joints, where the whole arm or knee is exposed to this type of hyperemia for orthopedic exercises, expensive apparatus is necessary

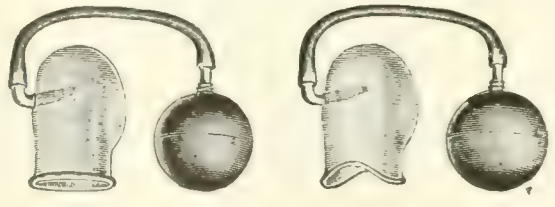


Fig. 3335.

(Figs. 3339–3341). All these cups are made by Eschbaum and are now to be had in this country.

As the suction in inflammatory cases draws out pus, bacteria, etc., the cups are very regularly contaminated. Cups such as shown in Figs. 3334 to 3337 are designed to prevent the entrance of infectious materials into the rubber ball or rubber tubing. The cups must be kept clean by boiling or by use of antiseptic solutions. In using the very large vacuum

glasses for orthopedic purposes, naturally no such measures are necessary, as these cups are not contaminated. They are not employed in the treatment of inflammatory diseases, but are apparently of use in stretching stiffened joints and adherent tendons by virtue of the pressure exerted by the atmosphere. This is most clearly seen in Fig. 3341.

On the other hand, venous hyperemia produced by constriction requires very little in the way of appliances. A thin rubber bandage suffices for all extremity cases except the most proximal parts. In the hip there is no way of producing this type of hyperemia; whereas in the shoulder-joint, as shown in Fig. 5187, a rubber tube must be employed. To produce hyperemia distal to the neck elastic webbing is used. These neck bands are so arranged with hooks and eyes that their tension can be readily regulated. It is evident that this useful type of hyperemia can be employed without any great expense, and for the benefit of those who wish to try this new therapeutic agent I can say with perfect honesty that they need not purchase at once a great variety of suction cups; a few sizes and shapes, *e.g.* such as are represented by Figs. 3333, 3336, 3338, and a Martin's rubber bandage, two and one-half inches in width, will suffice to begin.

Fig. 3336.

Fig. 3337.

Fig. 3338.

Technique of Suction Hyperemia.—After making a small incision provided pus is present (and gently squeezing this out*) the cup is applied. Two cardinal rules must be followed. The application of the cup must be painless and intermittent. If the suction is extreme it causes pain and damages the tissues. In acute inflammatory conditions the suction should regularly be mild, whereas in more chronic conditions, especially over sinuses, one may exert considerable suction. Pain on the part of the patient is an indication of faulty application. Subcutaneous hemorrhages about the diseased focus are another sign of faulty technique. Just as important as the observation of painless application is the intermittent suction. Suction should not be continuous. There should be intermissions every four or five minutes, and then suction again for four or five minutes after a two- to three-minute pause. This routine is kept up for forty to forty-five minutes, and the whole constitutes one treatment. Such a treatment may be given once or twice a day. It is frequently advisable to grease the edge of the cup with sterile vaseline so that the cup takes better hold on the skin. The cups that are used for the fingers (Fig. 3337) or for the hands are supplied with a rubber cuff which must be made to enclose the more distal part snugly to permit of the production of a rarefaction of the air in the cup. While the cup is drawing on the exposed part, the latter becomes hyperemic and swells. It projects into the glass. The circulation of the exposed tissues becomes sluggish. The incised focus of the sinus discharges more or less freely. On removing the cup, which is done gently by squeezing the rubber bulb together or by allowing air in by the stopcock, the

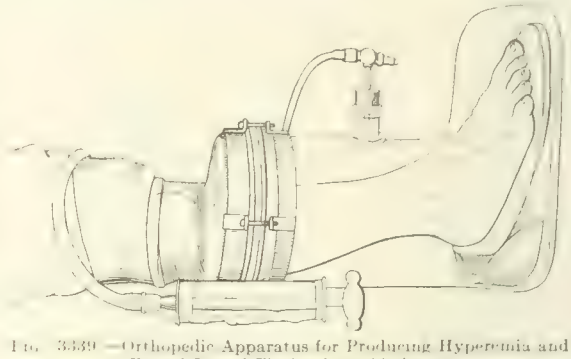


Fig. 3339.—Orthopedic Apparatus for Producing Hyperemia and Forced Dorsal Flexion in Ankle-joint

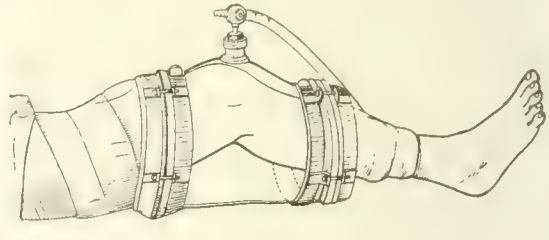


Fig. 3340.—Orthopedic Apparatus for Producing Hyperemia and Forced Flexion of Knee-joint.

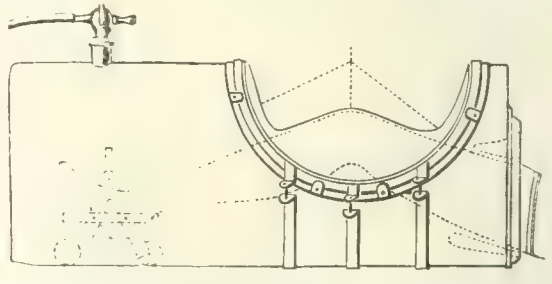


Fig. 3341.—Orthopedic Apparatus for Hyperemization and Stretching of Knee-joint.

* Bier advises pressing out the pus, which is not necessary either in suction or in constriction hyperemia, as both make for excellent drainage and painless evacuation of the inflamed foci.

exposed part has an opportunity to regain a more normal circulation. Fresh blood pours into it and some of the artificial edema disappears. After a short pause suction is again applied, and so on till the treatment is concluded.

To make the technique absolutely clear I will briefly narrate three cases that were treated by this suction method. These will illustrate more graphically just how to use the cups and at the same time show some of the advantages of suction hyperemia.

Case I.—F., thirty-five years. For one week the patient has had a painful, red swelling on outer side of forearm. This has gradually grown in size. When I first saw it it measured about one and one-half inches in diameter and fluctuated. Diagnosis: Abscess. After selecting a properly shaped cup which would encompass the whole area of inflammation, I made, under local anesthesia, a one-half-inch incision over the middle of the abscess and at once applied moderate suction hyperemia, without producing any pain. Large quantities of pus and of blood discharged into the cup, and after four or five minutes' suction the cup was removed. After two or three minutes' rest the cleaned cup was reapplied as at first and more pus and blood discharged. The adjacent skin became deep red in color and the whole area became turgid with congested blood. After four or five minutes' suction another period of rest and then suction again. After doing this for forty to forty-five minutes, suction no longer withdrew pus and the small incision was choked with blood clot. The arm was then dressed with a wet dressing, *no drain being used*. The patient declared that after all the manipulation her arm felt much better and almost all the pain had left. As the patient was sufficiently intelligent to make proper use of the cup, I gave her the cleaned cup to apply as I had done. She employed it that evening, and returned to me next day for the third treatment, which was scarcely required. Almost all signs of inflammation had disappeared. There was very little tenderness or redness. The swelling had gone down. There was no pus. For safety's sake I gave her one more treatment and applied a light wet dressing. In this case, within thirty-six hours after the incision, the inflammatory focus had practically disappeared without causing the patient any of the usual pain incidental to the older methods of treatment by broad incision and packing.

Case II.—F., twenty years. Three days previous had been manicured. Since then painful, red swelling about nail, especially over the matrix. Since this morning there was a slight discharge of pus from below the cuticle. Diagnosis: Paronychia. As the focus was discharging, I immediately began to employ suction hyperemia without incising, using the cup represented in Fig. 5181. The same technique was employed as in the previous case. Some pus and bloody serum discharged. The finger became red with the slightest tinge of blue. The next day and the day following I used the cup again, bandaging the finger with a wet dressing between treatments, and by that time the infection was controlled and the patient was discharged.*

Case III.—M., fifteen years. Has sinus over head of tibia following operation for supposed tuberculosis of the bone. The sinus, which was one and one-half inches long, did not lead to bare bone. Diagnosis: Postoperative sinus. After greasing the lips of the small sinus cup with sterile vaseline to assist in gaining proper apposition, the treatment as above outlined was carried out. Suction was applied. Serum and blood escaped into the cup and the granulations became turgid. After one such treatment the sinus was closed so that when seen two days later no further suction therapy was necessary.

In the use of the very large cups for orthopedic purposes Bier gives less explicit rules. The part to be exercised or stretched is first made hyperemic and after this is thoroughly done the air is rarefied even more, the degree of rarefaction required being tested on one's own arm, or other part first, or by close scrutiny of the patient's limb. The atmospheric pressure forces the limb into the vacuum; as, for instance, in the case of a plantar-flexed foot the pressure would force the extremity against the glass base and thus stretch the involved parts, gradually extending the foot further and further, until pain becomes too severe or complete extension has been obtained. The same process of stretching is carried out in this way in the knee-, wrist-, elbow-, and finger-joints with the proper appliance. Special instruments with spiral groove and fitted with a hand piece to develop supination and pronation are warmly recommended by Bier.

* In some hand cases large hand cups are very useful in producing hyperemia.

Technique of Constriction Hyperemia.—Though the constricting bandage has been used a great deal, the exact application of it is still difficult. Henle tried to simplify the technique by using a rubber tube connected with a manometer. This can be applied to produce the same pressure each time after one has determined the pressure one desires in the particular case. Bier finds this useful in difficult cases. As a rule, a thin rubber Martin's bandage suffices. This is applied over a piece of gauze or directly to the skin, one fold of the bandage overlapping the other. The end of the bandage is fixed with a safety pin. The exact tension of the bandage is best studied on one's own arm. Such a preliminary study prevents many awkward experiences for the physician and many painful moments for the patient.

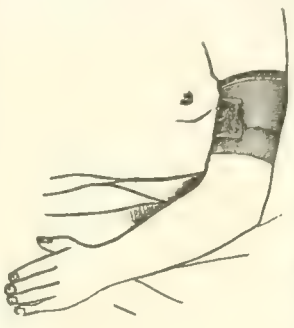


Fig. 3342.

Though Bier does not specify accurately that these constricting bandages are applied differently in chronic and in acute conditions, still his reference to the treatment of tuberculosis, and my own extensive experience with his methods, have led me to use firm constriction in the more chronic cases and mild constriction in acute cases. (See below, Indications for Constriction Hyperemia.)

The technique is very similar, though much more difficult in the acute cases. It is undoubtedly due to this, and to the fact that such cases require most careful watching, that the hyperemia method has not geen generally adopted. The bandage is wrapped about the limb proximal to the diseased part, as described above, and the tension is regulated by the subjective and objective symptoms. In chronic cases the bandage is applied firmly until the veins stand out and the part distal to the constriction becomes reddish blue in color. Such an application should not produce a mottling of the skin, nor an appearance of dull-red spots. It should not cause pain, only a sensation of fulness of the engorged part. After forty-five minutes to an hour the patient may have some paresthesia. In chronic cases, treated with firm application of the bandage, a treatment should last only forty-five minutes to an hour. If the proper degree of constriction is not obtained the bandage must be loosened or tightened as the case may be. The pulse should never be affected. After removing a bandage applied in this way, the limb becomes bright red, and arterial hyperemia sets in. This reaction, whatever may be its physiology, whether due to a vasomotor paresis or to a specific "tissue thirst" (Bier), I believe is most important in the treatment of chronic cases. As yet it has received very little attention.

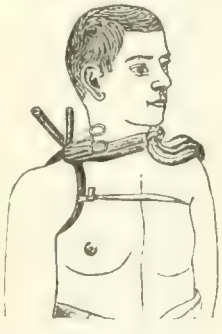


Fig. 3343.

As said above, the application of the bandage in acute cases is in many respects similar to that in chronic cases. The bandage is applied very lightly so as to produce a mild venous congestion and edema of the distal part. If a cellulitis is being treated, such a bandage properly applied produces an exaggeration of all the local signs of inflammation, up to the production of an intensely red, "fiery red" edema. The part never should be as blue as in the chronic cases,

though occasionally there may be a tinge of blue in the deep-red coloration. This bandage should not cause pain, and usually relieves it. It remains in place for ten to twenty hours at a time, producing a marked swelling of the limb, and during the intervals between applications, two to four hours daily, the edema is allowed to subside, elevation and massage (rarely) being employed to assist. It must be remembered that the fiery-red reaction in acute cases becomes less and less marked as the focus of inflammation is controlled. This lessening of the reaction is indicative of improvement, and if it fails to take place, Bier says an abscess that should be incised is present.

As the bandage remains in place in most acute cases for ten hours, in severer cases twenty hours, at a time, naturally its position must be shifted at successive applications to avoid pressure sores and atrophy of the deeper parts (muscles). It is advisable to select two levels and to apply the bandage first at one and then, after the pause between applications, at the other. If the second application be made distal to the first the bandage will have to be tightened repeatedly as the edema caused by the first application disappears.

Another point to bear in mind is that the applications are gradually shortened as the cure progresses. Sudden cessation of treatment may lead to a recrudescence of the trouble, so that it is well to keep up the treatment for several days after the signs of inflammation have subsided.

Although in some cases the proper application of the constricting bandage may effect a cure without incision, it is advisable to make small openings into all pus foci before commencing hyperemia treatment. *Whenever there is pus it should be evacuated by incision.* The incisions, however, should, as a rule, not be drained. *Gauze drains should never be used.* Occasionally rubber tubes are needed to keep the incisions wide open and to permit of the proper drainage of the artificial transudate into the dressing. In treating acutely inflamed parts with constriction hyperemia, many fail to get good results because the part that is diseased is bandaged so firmly that an artificial edema and hyperemia cannot be produced. The best and simplest method of enveloping the treated part is without a bandage. The limb is covered with gauze and the whole is then surrounded with a towel that is pinned together without exerting any pressure on the diseased tissues. If the area has been incised a voluminous dressing will be required to soak up all the discharge, which, as said above, is markedly increased under this therapy. In such cases as the latter, it is advisable to give the patient plenty of fluid to take the place of all that is washed out through the incisions.

In the more acute cases, after removal of the bandage the products of the local inflammation, toxins, etc., may be swept into the general systemic circulation and lead to constitutional symptoms which were not manifest while the bandage was *in situ*. Chills, increase in temperature, headache, malaise develop occasionally. Severe or dangerous intoxication or sepsis, as dreaded by Lexer, I have not seen. The opinion of those who are using this constriction hyperemia is gradually coming to the standpoint that I emphasized in 1906. All chronic cases that are treated with short applications may be so treated in the office or in the dispensary; whereas all cases that require protracted application must be carefully supervised and should be in hospital.

To illustrate the application of constriction hyperemia I will cite several cases both chronic and acute.

Case IV.—M., fifteen years. Had been operated upon for acute osteomyelitis of the tibia. The wound had never healed, and as bone was felt at the bottom of the sinus another operation was performed to remove the dead tissue. After this a sinus persisted for many months over the head of the tibia, and exposed bone was felt at the bottom of the sinus. At this stage I began treating with constriction hyperemia, using firm constriction for forty-five minutes, three times a week. The bandage was applied to the thigh just above the patella, and the leg was left exposed. The bandage was applied tight enough to produce a reddish-blue coloration of the leg without causing pain. Toward the end of the treatment, the patient complained of numbness in his toes. While the bandage was in place, the discharge from the sinus increased. After removal of the bandage the leg became bright red. The sinus was dressed with a wet dressing. No drain was used. Under this therapy the sinus gradually closed and in a month or so no evidence of diseased bone was recognizable.

Case V.—F., sixty years, had fallen from a ladder and received a compound fracture of her ankle, Pott's fracture. This became infected and was operated upon several times, pus being evacuated and bone removed. After four months of daily dressings with drainage the patient came to me. She had severe pain in her ankle and leg. She had no use of her foot, though its position was satisfactory. There was very little motion in the ankle joint. Sinuses ran down to the bone from all four aspects of the joint. There was chronic thickening with edema of the ankle and foot. Drains were immediately discontinued and a firm constriction bandage was applied, twice daily, for forty minutes about the thigh. This produced a marked venous congestion and induced freer drainage from the tortuous sinuses. Pain rapidly disappeared and motion in the joint became freer. Gradually the sinuses closed after discharging several particles of dead bone. Daily hot foot baths aided in hastening the absorption of the infiltrating edema about the ankle. Within six weeks of the beginning of treatment the ankle had assumed much more normal outlines, pain had ceased, fair motion had been restored, all but one of the sinuses had closed, and the patient was beginning to walk on her foot.

These cases illustrate the use of artificial venous hyperemia in which the bandage is applied firmly. In the treatment of tuberculosis of bones and joints, in endeavoring to stimulate callus formation in pseudarthrosis, etc., this type of hyperemia is employed.

Case VI.—M., forty years. No history of injury. Developed an acute painful swelling of right knee. Knee-joint was full of fluid and very tender. Temperature 104.5° and pulse 120–126. Aspiration of the knee-joint removed a thin purulent fluid which contained streptococci as shown in spread and in culture. A mild application of the rubber bandage on the middle of the thigh was begun at once. The bandage was tightened until the leg became red. It was left in place for twenty hours at a time and a massive edema developed. During the four hours that the bandage was off, the leg was elevated and much of the edema disappeared. During this period the patient's temperature gradually rose and then fell a little as the bandage was reapplied at another level. For several days the bandage was employed for twenty hours at a time, and then the periods were shortened as it became evident that the therapy was proving effective. Evidence of this was furnished by the gradual lytic fall of the temperature and the diminution of pain and of tenderness. In the course of two weeks the temperature became normal and the knee was freely movable, though still somewhat distended with fluid. It is interesting to relate that, though the inflammatory condition in the knee-joint cleared up so completely, two abscesses developed above the joint eading down to the fascia lata. These were small foci and in no wise connected with the joint. Judging from their situation, I suspect they were occasioned by the pressure of the rubber bandage. This is all the more striking as it is difficult to understand why the hyperemia cures the original focus and still does not prevent such a complication as the above in the hyperemic area. After incision these small abscesses closed, and in less than a month the patient was discharged with a perfect limb.

Case VII.—M., thirteen years. Shot three days prior to admission, bullet entering skin over left knee-joint. Pain, swelling, tenderness, impaired function, and fever developed. When brought to the hospital, the patient had a temperature of 103° and all the signs of an infected knee-joint full of fluid. The joint was opened by two lateral incisions and a large quantity of pus was evacuated. The bullet was found in the intercondylar area. The capsule of the joint was closed on both sides except for two small openings at which rubber tubes were sewed in place. The skin was closed similarly except at the site of the drainage tubes. An ample dry dressing was loosely applied and Bier's hyperemia was immediately instituted. The bandage was applied lightly, ten hours on and two hours off, then on again. The discharge was copious, and after two days active and passive motion was begun. This assisted in expelling the transudate that continuously collected in the joint and ballooned the cavity. After three days the tubes were removed and the same therapy continued, gradually cutting down the periods of constricting hyperemia, so that, within a week, the patient's temperature was practically normal, and within three weeks the patient was discharged with a normal knee-joint.

Case VIII.—M., twenty years, had been ill for almost a week with very marked swelling of the left leg up to the knee. There was fluctuation in the calf on the outer and inner sides. Here small incisions were made and over a pint of pus evacuated from

the abscess, which extended from the popliteal space to the os calcis. After drainage tubes had been placed in the incisions to keep them wide open and a loose dressing had been applied, hyperemia of the mild constrictive type was at once begun. A marked red edema developed under the bandage, which was used as in Case VII., ten hours on and two hours off. The drainage was astonishing. The tubes were rapidly shortened, and as the local conditions improved the treatments were shortened. In less than three weeks the patient's huge abscess cavity had completely closed and the leg was a normally useful member.

These last three cases will demonstrate in a general way the method of employing this type of hyperemia. The main points in technique that they emphasize are: (*a*) Light, painless application of the bandage so that the part becomes edematous and red—looks more inflamed than before; (*b*) incisions where there is pus; (*c*) loose and copious dressings; (*d*) gradual shortening of the periods of treatment; (*e*) tube drainage only if necessary to make incisions gape.

Before discussing the advantages and the various criticisms of these methods that are grouped under the name of Bier's hyperemia, it is essential that an analysis be made of the various conditions in which these types of hyperemia have been used. The total number of treated cases is naturally beyond computation, as so many are using the method. A review of the conditions in which hyperemia has been used, with a description of the results obtained, naturally must precede a discussion of the relative advantages of these over other methods.

Indications.—*Arterial Hyperemia* is particularly useful in conditions associated with or due to poor local circulation. As it relieves pain and assists absorption, it is also used when these activities are required.

Neuralgia. The use of heat is an old household remedy in various types of severe pains, and the hot-air douches are an effective method of employing heat. These are employed in all types of neuralgia, *e.g.* facial, sciatic, and they undoubtedly bring relief and occasionally they may cure. How often they effect a permanent result cannot be said with any accuracy.

Chronic Rheumatism. The use of superheated air in this condition is a well-recognized therapeutic agent, and there can be no denying its beneficial action even if it does not regularly prove effective. This method of treatment in such cases obtains almost everywhere. In this condition the artificial hyperemia leads to absorption as well as to relief of pain. Bier emphasizes the fact that if many joints are treated, each joint should be exposed a short time, or the worse joints should be selected and treated for thirty minutes; for very protracted treatments of each joint are liable to lead to constitutional effects, neurasthenia, anemia, and general enfeeblement. After using this therapy for several weeks or months it is discontinued, and for one to four weeks the joints are envloped each night in wet dressings or in irritating, hyperemia-inducing fomentations. Bier prefers constriction hyperemia to this arterial hyperemia in the acute exacerbations of chronic rheumatism and in involvement of smaller joints, *e.g.* elbow, hand, or finger.

In arthritis deformans Bier believes he has seen good results. Personally, I have seen no real benefit in this condition from arterial hyperemia, though pain may be relieved temporarily. Others, including Habs, Bum, and Leyden, have seen good results in chronic rheumatism, but nothing in arthritis deformans.

Posttraumatic stiffness of joints is beneficially influenced by hyperemia. Bier uses hot air in these cases and obtains rapid improvement. Motion increases and pains cease. Everybody has seen excellent results following the use of hot baths that induce well-marked hyperemia, so that it is needless to waste many words on this subject. In addition to hot-air therapy, Bier employs the large orthopedic suction cups to stretch the joints, and also constriction hyperemia, as will be seen later.

In scoliosis Klapp has employed hot-air treatment to assist in loosening the more or less fixed vertebral column. This combined with gymnastic exercises he considers the best therapy thus far discovered.

Gonorrheal rheumatism in the more chronic stage is beneficially influenced by arterial hyperemia, according to Bier. In the more acute stages constriction hyperemia is indicated. In these difficult cases hyperemia ought surely to be tried, as it will relieve frequently. It is, however, no panacea and, in my experience, frequently fails to do anything just when most needed.

In the reparative stage following acute infectious osteomyelitis and suppurative tenosynovitis, short daily applications of hot air are beneficial in stimulating rapid repair of the injured tissues. Hot baths do practically the same thing and are simpler. In the latter way most surgeons have employed arterial hyperemia for this class of cases a long time.

In senile and diabetic gangrene the use of arterial hyperemia will frequently lead to a rapid demarcation, and if the process is just beginning such hyperemia may save the limb. In the form of hot baths this type of hyperemia has long been used, especially in the limited processes, *e.g.* in gangrene of a toe or in diabetic mal perforant. In such cases short applications of superheated air beginning with low temperature may produce practically a *restitutio ad integrum*.

In skin conditions, *e.g.* frost bite, chronic eczema, psoriasis, arterial hyperemia induced by hot air has led to good results.

To hasten absorption of extravasated blood, edemas, chronic hydrops (non-tuberculous) of joints, hemarthrosis, Bier employs hot-air hyperemia and obtains excellent results. He mentions a large number of cases in which this therapy was employed effectively. In chronic edema of the lower extremities due to varicose veins, and in varicose ulcers, good results follow arterial hyperemia. I have regularly used cardiac stimulants to improve the local circulation, and these with nitroglycerin probably worked much in the same way as hot-air therapy. In recent thrombotic cases Bier advises against arterial hyperemia. In cases of thrombosis of the deep veins it is well to be chary in the use of superheated air, as in one case of thrombosis of the femoral vein treated in this way six months after the thrombosis Bier, lost his patient from a pulmonary embolus.

In fresh fractures and in fresh injuries to soft parts, Bier uses daily hot-air therapy for one hour, as it hastens absorption of extravasated blood, etc., and he believes it surpasses massage in efficacy.

Suction Hyperemia.—This type of hyperemia is used in a great variety of conditions both acute and chronic, both in general surgery and in the specialties. It has been received with great favor by most of the profession and is destined to be a useful therapeutic agent. Among the more important conditions in general surgery in which it has been successfully employed are the following:

In prophylaxis against infection this type of hyperemia is as old as the birth of the higher animals, that have always employed their lips to suck freshly inflicted wounds. To prevent infection of incised or of not overdeep perforating wounds there is no better agent than suction hyperemia. Its regular use undoubtedly will obviate many an infection and save many a patient and many a surgeon much pain and loss of time.

In stitch-hole infections there is no therapy so effective, so simple, and so rapidly curative. Incisions are rarely required, and extensive abscess formation is usually prevented by an early use of suction hyperemia.

In abscesses, furuncles, acne, infected wounds, cellulitis of fingers or of hand one almost regularly succeeds in curing the condition with small incisions into the pus foci and regular use of suction hyperemia. In some of the more extensive cases of cellulitis, occasionally also in cases of paronychia, the mild application of a constricting bandage—constriction hyperemia—is decidedly more effective than suction hyperemia. In those cases of deep infection of the fingers—so-called panaritium—constriction hyperemia should be regularly employed, as some have reported poor results with suction hyperemia.

In suppurative mastitis suction hyperemia has scored a triumph, even though in every single case it may not be successful. Instead of the old radial incisions and copious gauze drainage, small incisions into the pus pockets, and suction hyperemia with large cups encompassing the whole breast, lead to rapid cure without mutilation and painful dressings. In puerperal cases the milk should be withdrawn before each hyperemization of the breast. Occasionally, after one focus has been healed a fresh one develops and must be treated in the same way. The end result is almost regularly excellent both functionally and cosmetically.

In carbuncles, especially the non-diabetic, the best of results have been published. In these no broad incisions are demanded. Suction draws pus out of the many suppurating areas and a rapid cure is effected. (Bier, ten to fifteen days.)

In diabetic cases special care must be observed, as the tissues may not bear this therapy. Grube and Körte have employed artificial hyperemia in diabetics without injury, whereas Colley saw gangrene of the skin following its use. The last word has not been spoken concerning this group of cases, but the varied results surely prompt us to be very cautious.

In acute suppurative adenitis, especially in buboes, one frequently obtains rapid results after incising the purulent focus. If many glands are involved, and there are multiple pus foci scattered through the different glands, hyperemia may fail to accomplish anything. In these cases preliminary use of poultices followed by small incisions and then by suction hyperemia with large cups will usually prove effective. In some cases every attempt will fail and recourse to wide incisions and excision of the suppurating glands will be finally necessitated.

In acute bursitis, especially suppurative bursitis, suction hyperemia works well. If pus is present a small incision followed by hyperemia will lead to excellent results, painlessly and rapidly.

In infected hematomata and in contusions, suction hyperemia is very effective. In infected hematomata, suction hyperemia, after a small incision, is exceptionally useful. The suction evacuates clots and fluid blood rapidly and painlessly. In black eyes this therapy leads to rapid oxidation of the extravasated blood and prompt absorption.

In more chronic inflammatory conditions, *e.g.* chronic sinuses both tuberculous and non-tuberculous, suction hyperemia has scored a distinct success. Bier and Klapp regularly use it in fistulous bone and joint cases of tuberculous causation. In sinuses leading to tuberculous glands I have seen rapid healing without excision of the gland. I have seen good results in fistulæ about the anus. Applications over tuberculous glands through the skin, if the glands are subcutaneous, may be of use. I have seen such glands become smaller and firmer under this therapy.

In keloids Bier and others report absorption of the tumor. Although I have failed signally in this condition, a positive result is more valuable from a therapeutic standpoint than a negative one. In view of the successes of Thomas and of Bier, suction hyperemia should be tried in keloids.

In the removal of foreign bodies, *e.g.* pieces of glass, splinters, etc., it is almost self-evident that suction will assist, not only in drawing out the foreign matter, but also in producing a local immunization and thus prevention of infection.

In orthopedic surgery the very large cups are employed. So far as the use of these large suction cups is concerned, very few have had any experience with them, so that we shall have to confine our remarks to the statements of Bier and Klapp. They use these large cups to stretch joints that have been rendered more or less stiff as the result either of trauma or of rheumatism. The combined action of the hyperemia plus pressure of the atmosphere produces marked changes and restores excellent motility. Bier advises against the use of these orthopedic cups in joint tuberculosis so long as the disease is active. In tuberculosis of the knee with marked flexion deformity, however, Bier employs these cups to assist in overcoming the deformity even though the tuberculous process is not quiescent.

In nasal, aural, and ophthalmological surgery this type of hyperemia has been employed to some extent, but until more publications are forthcoming no final verdict as to its usefulness will be possible. In both the nose and the middle ear anatomical conditions are such that it is not easy to duplicate the suction hyperemia induced on other surfaces. In various types of tonsillitis good results have been reported. Of eye conditions treated in this way very few reports have been published.

In gynecology suction hyperemia has been employed quite extensively. Its field of usefulness is still undetermined. It has been used in chronic endometritis, perimetritis, and metritis, with more or less success. In amenorrhea the results have been variable.

Constriction Hyperemia.—As was said in the discussion of the technique of this type of hyperemia, the rubber constricting bandage should be applied very lightly in acute cases, and more firmly, producing more marked venous congestion, in the treatment of more chronic cases. In the following conditions the firm application of the bandage has been employed to induce a marked venous hyperemia and thus a cure of the pathological condition. Later the applicability of the milder constriction hyperemia will be discussed.

Pseudarthrosis.—In delayed union of fractures due to deficient callus formation, constriction hyperemia has frequently been of great benefit. This use of a constriction proximal to the threatened pseudarthrosis is very old. Ambrose Paré, Dumreicher, and Nicoladoni recommended it. Herferich in 1881 used this type of hyperemia for insufficient callus formation after fracture; also in insufficient involucrum production after bone necrosis. Thomas has made use of it to obtain firm union in fractures.

This method of treating the condition under discussion is simple. The part is bandaged in flannel up to the site of the fracture, and proximal to the fracture the rubber bandage is applied. This technique localizes the activity of the venous congestion at the point of fracture. Of course, this application is not always feasible if the fracture is so situated that a distal flannel bandage cannot be used, nor is it absolutely necessary.

In view of the painlessness, simplicity, and lack of danger of this method it should regularly be used, and judging from my own experience, employing it as I do in all delayed unions as a routine procedure, I believe patients very frequently will be spared more serious, uncertain, and dangerous methods which are used to accomplish the same result.

In chronic suppurating osteomyelitis, especially cases that have been operated upon or cases following compound fractures, venous congestion without the use of drains in the sinuses, which are regularly present, leads to most gratifying cures. The illustrative cases cited above are instances of the beneficent action of venous congestion in this class of cases. The

necrotic bone, provided, of course, the size of the sequestrum permits, is after a rapid separation from healthy tissue discharged through sinuses. Congestion leads to better drainage from within, and after removal of the bandage the reactive hyperemia in turn has a good effect.

In tuberculosis of bones and of joints the therapy under discussion was first tried. According to Bier's statement in February, 1912, at the Berlin Surgical Society, he had given up the ten- to fifteen-hour sessions of constriction in the tuberculous cases and advocated strongly the one- to two-hour sessions, as described above. This change was made to avoid the development of cold abscesses, large granulomata and secondary acute infections which followed the older long constrictions. He had thus come to the position advocated in this review, especially, that chronic cases require short and more intense applications, while long applications of a mild constriction are required in the acute cases. He now combines "eine kräftige Stauungshyperämie" with use of iodides (three grams pro die) and again uses longer applications. Wohlgemuth and Hollaender also reported good results in tuberculosis with this combination of hyperemia and iodides. Whether Bier will again modify this therapy after further experience time will tell. It is in use since July, 1911, and he believes the use of iodides prevents the abovementioned accidents, when employing twelve-hour (divided into three sessions) daily constriction (*Deutsche med. Wochensch.*, 1912). As said under suction hyperemia, fistulous cases are treated with suction and constriction hyperemia. This therapy has led to excellent results not only in Bier's clinic, but also in the hands of v. Eiselsberg, Kocher, Habs, Luxembourg, Tillmanns, and Henle (Mikulicz). There seems no reason to doubt the efficacy of this therapy in this class of cases, from what I have seen in my own work. To get a good idea of Bier's results it is worth while enumerating his series of cases:

1. Carpal Tuberculosis; 17 cases. Of these 4 had fistulæ. In 5, abscesses developed during the treatment and were opened. Results: Fifteen cases cured, 3 had perfect motion, 2 were improved. Average duration of treatment twelve months.

2. Elbow-joint Tuberculosis; 11 Cases. Five had fistulæ, 8 developed abscesses that were incised. Results: Eight cases cured. Normal motion in no case, though in all it was adequate. The worst result showed a mobility of from 50° to 115°.

3. Tarsal Tuberculosis; 13 cases. Eight had fistulæ. In 6 cases, abscesses had to be opened during treatment. Results: Eight cured, 3 improved, 1 unimproved, 1 came to amputation. Perfect motion in 3 of the cured cases, satisfactory in the others. Duration of treatment averaged ten months.

4. Knee-joint Tuberculosis; 5 Cases. One had fistula. Results: Three were cured, 2 with perfect motion, 1 was fixed in good position, 2 were improved. In 8 other knee cases after short trial with hyperemia Bier did a resection.

5. Shoulder-joint Tuberculosis; 1 Case. Result: Cure with perfect motion.

From these data it is evident that this conservative method of treatment leads to excellent results in carpal, tarsal, and elbow tuberculosis. In the knee-joint the results of this therapy are not good.

While employing this method of combating tuberculosis the involved part is not immobilized, as one of the objects of this whole therapy is to obtain a good functional limb. In the lower extremity I do not feel ready to abandon removable splints. One cannot gainsay that Bier's treatment requires a great deal of time, nine months on an average, but all conservative measures in these cases are very slow in effecting a cure.

This therapy is contraindicated, according to Bier, in (1) amyloid degeneration; (2) severe pulmonary tuberculosis; (3) large distended pyarthrosis (knee); (4) faulty position, when operation will give better end results. In tuberculosis of bones Bier regularly operates unless such a procedure would interfere with the function of the part. In cases of spina ventosa Klapp has been successful with suction hyperemia.

Tuberculosis of the testis Bier has subjected to venous hyperemia by tying a rubber band or tube about the root of the scrotum. If both testes are involved both are treated simultaneously otherwise only the diseased organ. The hyperemia is induced for one to three hours daily, and the scrotum is supported by a suspensory. Bier has seen the best results in fistulous cases. He has published no convincing data up to date, so that it is proper to reserve judgment, especially as he says the therapy is less efficient in beginning tuberculosis of the epididymis. He recommends the same hyperemia therapy for tuberculous disease of the tendon sheaths and skin, and for lupus.

In stiff joints following contusions, fractures, healed cellulitic area, etc., I have been pleased with this therapy. Bier recommends the mild application for ten to twenty hours at a time. This I have not employed, as these patients are not willing to give ud the time necessitated by such long applications. With three-quarter to one hour treatments, and marked venous congestion, good results can be obtained and the patient need not enter a hospital for surveillance. While the bandage is in place, active and passive exercises are carried out and motion is gradually increased by stretching the hyperemic tissues. Because of the anesthetizing effect of the hyperemia the parts can be more readily moved and the involved tissues stretched with less discomfort.

In vague joint cases in which the diagnosis is obscure, as well as in old rheumatic cases and chronic gonorrheal joints, this firm application of the bandage can readily be employed without putting the patient in a hospital. Bier favors long applications of the milder constriction hyperemia. Which method is better I cannot say. The method I have used is simpler and liable to appeal to the patient, if the results are equally good.

In addition to vague joint cases, there are many other posttraumatic vague neuralgic or painful conditions in the extremities which, strange to say, are benefited by this therapy. The diagnosis is never made, but the patient gets well.

It is in interpreting the curvative effect of the milder constriction hyperemia that one must be particularly guarded. There is no doubt that one sees most astonishing results in the most diverse acute conditions under this therapy, and to be strictly scientific in the face of these is often practically impossible. In the following conditions it has been repeatedly employed, and found favor.

Prophylaxis against Infection. As mentioned under the uses of suction hyperemia, in this field we have a very useful agent in artificial hyperemia. While suction hyperemia is useful in the smaller injuries, in the more extensive wounds of extremities constriction hyperemia must be employed. As a prophylactic agent hyperemia has proven to be our very first and most effective agent. Prior to its introduction the surgeon did little or nothing in the treatment of fresh wounds that could be interpreted as truly prophylactic against infection. If a patient acquired a compound fracture and the ends of the bone pierced the skin, the surgeon could rely on seeing an infection, perhaps a most serious infection that would lead to incision and drainage, at times to amputation or to death. Now in hyperemia, in the mild constrictive type of hyperemia, I believe we have at last an agent that will produce a local immunization and prevent in many cases the development of a serious or even slight infection. The most striking instance of the efficacy of this therapy that I have seen

was in a case of fracture of the fibula and tibia. Both bones perforated the skin, and their fractured ends were thoroughly contaminated. After replacement of the broken bones Bier's hyperemia for twenty-hour periods was applied for at least ten days and a perfect recovery took place, as far as infection was concerned. Another series of cases in which I have employed this type of hyperemia to prevent trouble are the postoperative cases mentioned below.

This use of hyperemia I feel sure will be a boon to humanity—it markes a distinct advance. As yet the literature has paid but scant attention to this subject.

Acute Inflammations: (1) Cellulitis, lymphangitis; (2) Tendon-sheath phlegmon; (3) Suppurative arthritis; (4) Acute osteomyelitis; (5) Erysipelas.

The use of mild constriction hyperemia in the above inflammatory conditions is one of the most important developments in this field of therapy. Bier has seen the most remarkable results in all these conditions, but even he must admit that hyperemia may not be effective in some cases. To any one who has read the literature of this subject, even if he has not employed the method and demonstrated to his own satisfaction the effects of this therapy, it will be clear that hyperemia accomplishes a great deal that our older methods did not accomplish as simply, as painlessly, and as rapidly. Still, until cases are reported with bacteriological examinations it will remain undecided whether hyperemia has an equally beneficent effect against all invading bacteria. Lexer deserves credit for bringing out this point when he claims that hyperemia does not work successfully against severe streptococcic infections. Although I have repeatedly seen this therapy cure infections due to streptococci, still we must in the future study this problem and determine whether our new agent is as effective against one type of organism as another.

Bier believes he has been able to cut short beginning suppurative processes with this method. His cited cases are not so conclusive as they should be, as I have seen similar pyemic deposits disappear without therapy just as rapidly. In fact, only recently on one patient, who had pyemic deposits in several extremities, I compared hyperemic treatment with no treatment at all. The different deposits did equally well. Hyperemia was no more effective than leaving nature alone. Though I have not seen very severe cases of cellulitis disappear without suppuration, I have seen milder cases behave in that way. There is no doubt in my mind that this therapy will cut short many an acute postoperative infection of an extremity. Here it is the only agent we can avail ourselves of, and I have repeatedly employed it to prevent suppuration. It is particularly useful after joint resections, and in these it might even be used prophylactically to insure a good result.

Good results following the use of this constriction hyperemia in acute inflammatory conditions have been reported by Habs, Körte, Sick, Stich, Danielsen, Bardenheuer, Heidenhain, Lexer, Heller, Haaster, Losser, Derlin, v. Brunn, and others. I have used Bier's methods in considerably more than 400 cases, of which over 100 were acute inflammations, and I have usually seen excellent results. The great difficulty that we meet with is in deciding whether the results are due to the hyperemia therapy. I have frequently been in doubt and have hesitated to ascribe all the *post hoc* developments to our therapeutic agent. Unfortunately, parallel cases and parallel observations cannot be studied. Although one has the impression that hyperemia almost regularly benefits, still it will require time and much more experience to furnish positive and irrefutable proof.

Cellulitis and lymphangitis cases seem to do well under this therapy. The pus foci naturally are opened, by small incisions if possible, before this treatment is begun, and, as said above, no gauze drains are employed, as gauze devitalizes the tissues with which it comes in contact. There is great unanimity of opinion that staphylococcus infections respond nicely to this treatment, whereas streptococcus infections may be less easily controlled. Lexer and Sick have emphasized the latter.

Tendon-sheath infections have been very successfully treated. The avoidance of gauze drainage and the constant bathing of the tendons in plasma frequently save tendons which would under the old therapy become necrotic. Bardenheuer, after extensive trial, is most enthusiastic, having had exceptionally good results. He states that if nothing else had been effected by this new therapeutic agent, its excellent effects in tendon-sheath infections would establish a place for it in our therapeutic armamentarium.

Suppurative arthritis cases have frequently done well. As shown in one of my illustrative cases, the joint may not require incision, though usually it will be safer to aspirate and wash out or even to incise whenever there is pus. In addition to Bier, Bardenheuer, Habs, and many others have reported good results.

In acute osteomyelitis considerable difference of opinion exists. Some have had good results, others have not. Garré's advice to open the bone in the usual way will probably be followed until more convincing proof is presented that hyperemia with small incisions, or aspiration, or hyperemia alone can effect a cure. I personally am a little loath to follow Bier in this field, though he reports some remarkable results, in which the focus in the bones healed, and frequently without necrosis. For when the process has extended from the marrow into the bone itself, I fail to see how we can produce an adequate hyperemia in the dieased tissue. It may be possible to effect an inflammation that is limited to the marrow, though even here it must be difficult to induce hyperemia and edema at any but the earliest stage of the disease.

In erysipelas the claims of hyperemia are even more doubtful. Bier was inclined to think it useful in this condition. Now even he is in doubt. Hochhaus and Sick have been pleased with its effect. In my experience some cases get well rapidly under this treatment and others are not affected. Those that get well rapidly frequently show a lytic fall in temperature, which is about the only symptom that might induce one to ascribe the result to hyperemia; but as many cases of erysipelas behave in other points just as those treated with hyperemia, it surely is dangerous to express a favorable view of the therapy in these cases. Moreover, it has frequently been noted that acute inflammatory cases develop erysipelas under hyperemia therapy. Provided these are real erysipelas cases this would speak against the efficacy of hyperemia therapy in such a condition.

Acute Conditions (Inflammatory) of the Head. Under these are included mastoiditis, otitis media, parotitis, parulis, meningitis, lymphadenitis, coryza, tonsillitis, dacryocystitis. Bier says in all these conditions he and others have seen good results. Here the bandage or webbing surrounds the neck and produces thus a hyperemia of the distal parts. It is even more difficult to judge of the effect of the therapy in these cases than in most of the other inflammatory diseases just mentioned. Here prognosis is particularly difficult, for it is almost impossible to say accurately what would happen without hyperemia. In this category of cases, scepticism has every right to an excellent hearing. How frequently patients with mastoid symptoms get well without surgical intervention after they have been persuaded that they should go to the hospital for operation! It is more than difficult to understand how an adequate edema and hyperemia can be produced in the mastoid, especially when its cells are filled with exudate. Here

we encounter the same difficulty as mentioned under acute osteomyelitis cases. From what I have seen of the results of hyperemia treatment in the extremities, I see no reason to doubt that in inflammation of the soft parts and of the mucosa of the middle ear and of the nose, etc., good may be effected here also.

Chronic rheumatism, stiff joints following injury, gonorrheal joints are treated by this mild constriction hyperemia by Bier. As mentioned previously, Bier employs long applications of the constricting bandage for the acute attacks of chronic rheumatism and also for involvement of the smaller joints. He treats stiff joints similarly or with superheated air. As said previously, I have had good results in these cases treated in the dispensary with short applications and marked venous congestion. In gonorrheal joints the constricting bandage may at first increase the pain (Bier), but if the patient can be made comfortable this soon diminishes and the inflammation will subside. Opinions as to the efficacy of this therapy in all kinds of gonorrheal joints are still at variance. As some cases seem to respond, it surely should be given a fair trial.

In malignant edema this type of hyperemia should be employed. Both experimental and clinical work have demonstrated its efficacy against anthrax.

In the following conditions Bier has employed mild constriction hyperemia with some success: (1) acute gout, (2) insect bites, (3) chorea, (4) epilepsy, (5) subcutaneous hemorrhagic extravasations, (6) chronic headache. There seems to be some justification for his claims in acute gout, in insect bites, and subcutaneous hemorrhagic extravasations. The other conditions, however, require more study and further trials before a favorable opinion can be given.

Further Possibilities of Hyperemia Therapy.—Pulmonary Tuberculosis. It was quite natural that an attempt should be made to influence tuberculosis of the lungs. Both the autoptic material and Bier's clinical material seemed to point the way to applying hyperemia in this condition. The experience with bone and joint tuberculosis has demonstrated the value of venous congestion in this disease, and it would seem probable that pulmonary tuberculosis might respond to similar therapy. Unfortunately, as yet there is no method of producing a venous congestion in the pulmonary circuit, as emphasized some pages back. Even Bier admits that the blood in a congested lung must be mainly arterial, as it is rapidly arterialized in the pulmonary capillaries. Moreover, experience has shown that arterial hyperemia is ineffective in bone and joint tuberculosis. Despite this evident contradiction, despite the fact that clinicians in testing the effect of hyperemia in pulmonary tuberculosis are employing arterial hyperemia, which is ineffectual in bone tuberculosis, and are not producing a marked venous hyperemia, still their work may develop something of value in the treatment of this disease.

Kuhn's mask, which compels the patient to breathe under difficulty, inspiration against resistance, expiration unimpeded, producing a suction hyperemia in the lungs, is used for the treatment of pulmonary tuberculosis. Whether this will lead to any definite results time and careful observation alone will tell.

Suppurative meningitis has always appealed to me as likely to respond to constriction hyperemia, provided the exudate and transudate are very frequently withdrawn or drained from the subdural space. If a mild constriction hyperemia of the head be induced by a bandage about the neck, the brain and meninges become hyperemic and displace the cerebrospinal fluid that is within the cranium into the non-compressed spinal column. Such endocranial hyperemia produces in this way a marked increase in pressure in the spinal fluid. If in cases of acute meningitis this spinal fluid were frequently withdrawn, or constant drainage were made in the lumbar region, we might be able to influence the inflammatory condition, just as we do in peripheral infections. Cases of compound fracture of the skull and of basal fracture (W. Meyer) might be treated prophylactically with hyperemia with or without lumbar puncture, to insure against meningitis.

As yet the publications in this field are few and not in any way conclusive. In the few cases treated allowance has not been made for a proper hyperemization of the endocranial structures by frequent lumbar puncture, and till that is done nothing final may be said on this subject.

In addition to these two conditions many others will probably suggest themselves as amenable to hyperemic therapy. All new therapeutic agents when looked upon from every standpoint will be used in a variety of conditions for which they were not originally suggested, and perhaps will prove particularly effective in some of these.

Contraindications and Dangers.—These cannot be gathered and stated dogmatically at the present time. Superheated air must be used cautiously in all conditions associated with lowered vitality, and should not be employed in cases of thrombosis of the veins. Suction and constriction hyperemia should be used very cautiously in diabetics. In very severe streptococcus infections one should be guarded in relying exclusively upon these agents. In cases that do not respond to constriction hyperemia this should be stopped. This applies particularly to those acute cases in which there does not seem to be sufficient power to check the infective process.

The methods above described, provided these contraindications are avoided and provided the technique is perfectly applied, have very few dangers. Erysipelas may develop in the treated part. At the site of the bandage necroses of fascia or skin occasionally develop. Once I saw a deep-vein thrombosis at the site of the bandage in a streptococcemia case. Others have seen this also.

If the technique is faulty, naturally serious accidents may occur. Whenever a bad result is reported there is a distinct tendency to attribute it to faulty technique. No doubt many poor results are due to this, but the tendency to attribute all these to technical failures is a mistake. Hyperemia is surely no panacea and not infallible, so let us group all bad results together, whether due to the operator or the method, till we have some definite criteria to distinguish between these two sources of trouble. In practice the two are associated—the hyperemia demands an operator, and the therapy must be viewed in that light, rather than as a simple hyperemia unit.

Criticisms of hyperemia are based chiefly upon its therapeutic use in acute infections. The application of arterial hyperemia is rather generally accepted at its proper value. As hyperemia in acute infections marshals Nature's forces to fight the invader, it avails itself of Nature's weapons alone. If these are inadequate it will fail to win the battle. That is self-evident. Fortunately these forces are usually adequate.

Lexer's criticism of Bier's method in acute cases is more spirited than sound. He indulges in many theoretical points which were brought together to overwhelm this therapy just at the time that it was creating such a furor in Germany. Lexer claims that hyperemia assists in just those cases where older methods succeed as well. In severe cases it is dangerous, as it allows of a local culture of bacteria and a local destruction of tissues by the bacterial endotoxins. These points are still unproven, though, as frequently said in this essay, great caution must be observed in severe streptococcus infections, lest, relying on hyperemia too much, the patient 's interests suffer.

In the treatment of peripheral tuberculosis, Mosetig-Moorhof has taken the position that this hyperemia therapy is dangerous, as it may lead to a dissemination of the disease. As yet no cases have behaved in this way.

Another and more practical objection to Bier's methods relates to the time they demand. No suction treatment can be properly carried out in less than forty-five minutes. Constriction hyperemia in acute cases requires continuous watching for hours. This is a hardship for the busy surgeon, and will be one of the chief obstacles to the wide use of Bier's methods. By teaching patients how to cup themselves, by treating a number simultaneously, by placing others in hospitals under the eyes of the house staff, we can avoid this difficulty. Those who are not so situated that they can do these things will be slow to take up these new methods, unless they dread the older methods of long incisions which Bier has supplanted in the treatment of most cases.

Advantages of Bier's Hyperemia.—It is proper to close this essay by a brief reference to the advantages of the methods under discussion. As they have already been touched on in the course of this essay, it will suffice to enumerate them briefly.

Arterial hyperemia has a field of its own, and there are no therapeutic agents that have proven more effective in the conditions for which it is used.

Suction hyperemia in acute inflammatory cases avoids long incisions and painful and injurious gauze packing, and leads to a cure more rapidly than older methods. In prophylaxis both types of hyperemia are distinct additions, as prior to Bier's discovery we knew no method of avoiding infections after injuries. Like suction hyperemia, constriction hyperemia does away with long incisions and their resulting scars; it also frequently prevents necrosis and sloughing of tendons where older methods failed. Constriction hyperemia in acute infections usually shortens the time of illness.

Even if venous hyperemia did no more than provide excellent drainage from within outward, in acute infections I should employ it regularly as it avoids all painful manipulation of the infected area. As it accomplishes much more than drainage, I am all the more glad to make use of it.

In the more chronic conditions both suction and constriction hyperemia are very useful in just such cases as are mentioned in the previous pages, and that are frequently encountered wandering from pillar to post looking for relief.

With such marked advantages over older methods, with a broad usefulness in conditions, that up to date, have not been amenable to therapy, it does seem likely that artificial localized hyperemia, both arterial and venous, has come to stay, both as a boon to mankind and as an interesting field for scientific study.

Edwin Beer.

Hyperidrosis is a functional disorder of the sweat apparatus accompanied by a more or less excessive increase of the normal amount of sweat excreted. This increase may be local or general. Local forms are symmetrically confined to certain regions such as the palms of the hands, soles of the feet, axillæ, or genital regions. Cases of unilateral excessive sweating, confined to one side of the body wholly, have been observed, but they are rare; of more frequent occurrence, although still not common, are the cases of unilateral sweating limited to one side of the head or to one limb. Usually intermittent, the sweating in some cases may be continuous and is aggravated by hot weather, emotion, depression of general health, etc.; and the disturbance may be temporary or permanent, depending upon its exciting cause. Subjects of the disorder are nearly always in a lowered state of health, sometimes hysterical and often nervous. The direct causes which lead to local hyperidrosis are quite undetermined. Examinations of sections from the palms of the hand fail to show any abnormal features of either the glands or the epithelium. The disorder is to be regarded as purely functional, connected with a disturbance of the vasomotor control, no doubt, but as yet the exact links of the chain have not been definitely placed.

In the *treatment* of hyperidrosis, whether local or general, the condition of the patient's general health is of prime importance; the various ferruginous tonics, mineral acids, arsenic, strychnine, and quinine, are all of value. Belladonna and atropine, though but of temporary benefit, are of service at the outset of treatment in most cases. Cold baths for general toning of the circulation are strongly recommended. External treatment must be resorted to and is often very efficacious. In the local form that attacks the hands much benefit will be derived from immersing the palms for a few moments only in water as hot as can be borne, dabbing dry with a soft cloth, and then dusting on boric acid powder. The same treatment for the soles of the feet may be employed. A saturated alcoholic solution of boric acid dabbed on the palms during the day will control very well the excessive sweating of the hands that is so annoying to those who do much writing. Hebra's treatment for hyperidrosis of the feet consists of enveloping the feet, the toes separately, after thorough washing and drying, in strips of cotton cloth, over which is spread, to the thickness of a knife blade, his unguentum diachyli. The parts are well bandaged and the patient may subsequently either remain at rest or pursue his vocation, wearing shoes and stockings that have not been previously used. In twenty-four hours the feet are redressed without washing, after dry rubbing and a dusting powder. This process is repeated daily for from ten to twenty days, after which a dusting powder, preferably boric acid, may be substituted for the local dressing. There occurs a parchment-like desquamation of the skin in thick, yellowish-brown flakes, beneath which is formed a new and at first tender, but apparently normal, epidermis. When the latter has lost its tenderness, the feet are for the first time washed with water. The process is to be repeated in case of failure. Among the soldiers of the infantry of the German army, hyperidrosis is quite common and has resulted indirectly in the temporary disablement of an important percentage of men owing to maceration of the skin of the feet. To prevent this it is now the duty of each sergeant to inspect daily the feet of his men and to see the feet are washed with soap and cold water before and after each day's work. In addition, the soldiers are obliged to wear woolen socks in all seasons and to use as a dusting powder for the feet a combination of powdered talc and starch in equal proportions with from five to ten per cent. of salicylic acid. This powder is very generally used throughout Europe for hyperidrosis and gives excellent therapeutic results.

Prognosis in any case of hyperidrosis is uncertain. At times treatment may meet with brilliant success; again, it is followed by complete failure. The disorder may disappear spontaneously, only to recur and prove obstinate to all measures.

Charles Townshend Dade.

Hypermetropia—H.—Far-sight or hypermetropia (*ὑπέρ*, over, *μέτρον*, measure, *ὤψ*, eye) is that form of ametropia in which the principal focus of the eye, *i.e.* its focus for parallel rays such as come from a distant object, is situated behind the retina. In hypermetropia the anteroposterior axis of the eyeball is shorter than the focal length of the dioptric apparatus. By dioptric apparatus we mean the three refracting surfaces of the eye, namely, the anterior surface of the

cornea and the anterior and posterior surfaces of the crystalline lens. Fig. 3344 shows the essential points of difference between the emmetropic, myopic, and hypermetropic eye. In the normal or emmetropic eye the focal length of the dioptric apparatus corresponds exactly with the length of the visual axis, so that parallel rays are brought to a focus on the retina without accommodative effort. Such an eye

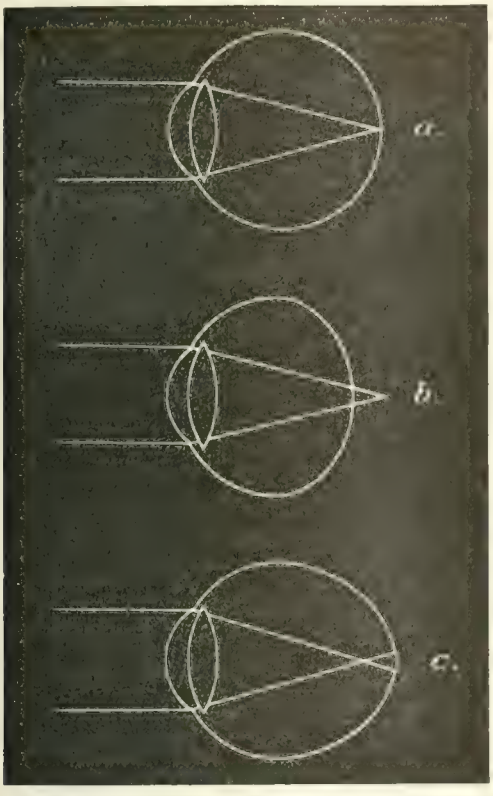


Fig. 3344.—Comparison of the Length of the Anteroposterior Axis in: *a*, Emmetropia; *b*, hypermetropia; *c*, myopia.

is perfectly adapted for both near and distant vision and glasses are not required for close work until about the forty-fifth year, when the power of accommodation loses some of its strength. The emmetropic eye has an average length of about 22 millimeters and, in a strict mathematical sense, is rare, occurring in not more than two per cent. of eyes. Any deviation from this ideal state of refraction is termed ametropia. When parallel rays focus in front of the retina the eye is *myopic* and when parallel rays focus behind the retina, the eye is hypermetropic.

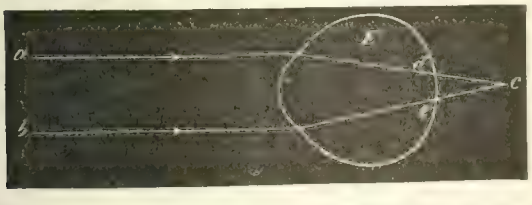


Fig. 3345.—Focus of Parallel Rays in Hypermetropia. (Swanzy.)

In hypermetropia (Fig. 3345) as the retina is situated in front of the principal focus of the eye, parallel rays come to a focus behind the retina at *c*, forming on the retina a circle of diffusion, *de*. Rays coming from any point *R* on the retina will emerge as divergent rays and if these rays are prolonged backward they will meet at a point *R'* (Fig. 3346) behind the retina. The point *R'* is called the far point, or the point for which the hypermetropic eye is adjusted when the dioptric apparatus is in a state of rest. The higher the degree of hypermetropia is, the nearer the far point is to the eye, and conversely, the lower the degree of hypermetropia, the farther the far point is from the eye. Hence, the distance of the far point behind the eye

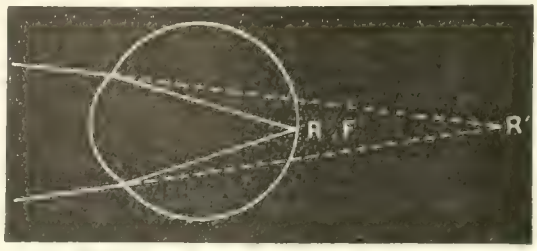


Fig. 3346.—Far Point of a Hypermetropic Eye.

will represent the degree of the hypermetropia. For example, if the far point lies fifty centimeters behind the eye a lens of fifty centimeters focal length (2 D) will render parallel rays so convergent that they will be brought to a focus upon the retina. To be quite exact, a slight allowance would have to be made for the distance of the glass from the eye. In myopia the far point lies in front of the eye (Fig. 3347) and as its distance from the eye is equal to the degree of

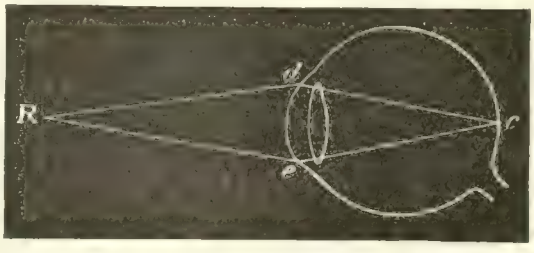


Fig. 3347.—Far Point of a Myopic Eye. (Swanzy.)

the myopia, the latter can be measured directly by finding the greatest distance at which fine print can be read. For example, if the distance is fifty centimeters then a concave glass of that focus (2 D) is the measure of the myopia. In hypermetropia the far point is an imaginary point behind the eye (negative) hence *H* can only be measured indirectly by means of convex glasses. As the emmetropic eye with its dioptric apparatus at rest is adjusted for the focussing of

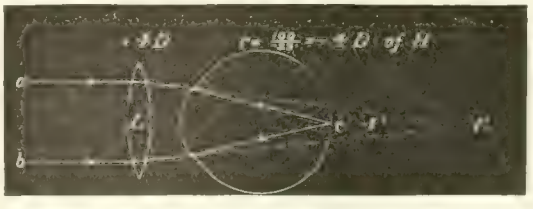


Fig. 3348.—Correction of Hypermetropia by a Convex Lens. *R*, far point; *r*, error of refraction, *F*, principal focus; *c*, point on retina when parallel rays are focussed by the lens. (Swanzy.)

parallel rays, so the hypermetropic eye is similarly adapted for the focussing of convergent rays. As all rays in nature are either divergent or parallel it follows that the hypermetropic eye, in a state of accommodative rest, is not naturally adapted for the focussing of any rays and consequently, both distant and near objects will appear blurred.

There are two ways in which parallel or divergent

rays can be rendered convergent and thus adapted for the hypermetropic eye, namely, by the use of a convex glass, or by an effort of accommodation. Fig. 3348 shows parallel rays rendered convergent by passing through a convex lens placed in front of the eye. The hypermetropic eye receiving and focussing such rays is practically equivalent to an emmetropic eye focussing parallel rays, and as any required degree of convergence may be given parallel rays by a convex lens of suitable power, so the vision of a hypermetrope may always be perfectly corrected for distance by wearing a convex glass of the required strength. Hypermetropia does not ordinarily manifest itself by impaired vision at a distance, at least in young persons, because the eye itself is able to make rays convergent by bringing into play its power of accommodation.

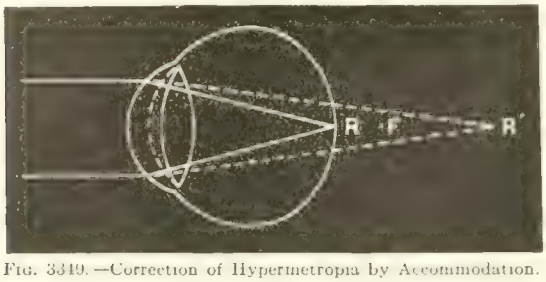


Fig. 3349.—Correction of Hypermetropia by Accommodation.

In Fig. 3349 the hypermetropic eye is adjusted for the focussing of parallel rays through the increase of the convexity of the crystalline lens incident to the act of accommodation. The focussing of the rays which form the retinal image is here as perfect as in the case shown in Fig. 3344, *a*, but with the difference that some part of the accommodation is expended in bringing the rays to a focus on the retina, so that there is less accommodation available for the further adjustment of the eye for near vision. From this it follows that the near point of the hypermetropic eye lies farther from the eye than the near point of the emmetropic eye and is therefore limited in its power of adjustment for near vision and the higher the grade of hypermetropia the greater the limitation.

Varieties of Hypermetropia.—It is difficult to determine the exact amount of hypermetropia for the reason that the hypermetrope is able to see distinctly by an effort of accommodation. Thus if we examine the same individual at different times for hypermetropia we may find that at first 1 D is the strongest glass accepted while soon afterward 1.5 D or 2 D may be chosen. If the muscle of accommodation is paralyzed by the use of atropine and the eye then tested it will be found that the hypermetropia is considerably higher than before—*e.g.* 3 or 4 D. The suppression of the greater part of the hypermetropia in young subjects is explained in this way—the hypermetrope necessarily makes use of some part of his accommodation in distant vision, besides being compelled to accommodate in excess of the normal degree in order to see near objects distinctly. He thus forms the habit of associating some degree of accommodation with the act of directing the eyes upon a distant object, and he generally continues to accommodate to some extent even when the proper glasses render this unnecessary. Hence it may happen that a hypermetrope will not only reject the convex glasses which accurately correct his refraction, but even the weakest convex glasses, and not infrequently this habitual tension or spasm of accommodation may be so great as closely to simulate myopia. The convex glass with which the hypermetrope sees most distinctly is not the measure of the total hypermetropia but only that portion of it which has been set free by the relaxation of the accommodation. This is called the *manifest* hypermetropia (*Hm*). The remaining portion which is concealed by the accommodation is the *latent* hypermetropia (*Hl*). The *total* hypermetropia is the sum of the manifest and the latent (*Ht* equals *Hm* plus *Hl*). The ratio between the manifest and latent hypermetropia is not constant but is dependent upon the extent of the range of accommodation, and therefore upon the age and vigor of the individual. In childhood and youth much of the hypermetropia is latent and consequently a cycloplegic is essential in estimating the amount of hypermetropia. The latent hypermetropia diminishes year by year and the manifest increases, until at the age of fifty-five or sixty the latent hypermetropia disappears and the total hypermetropia becomes manifest. In testing old people the convex glass which gives the greatest visual acuity at a distance of six meters is the measure of the total hypermetropia. The emmetrope at about the age of forty-five years has usually lost so much of his power of accommodation as to require convex glasses for reading at thirteen inches. The hypermetrope finds his near point receding beyond this limit of distance, but at an earlier age determined by the grade of hypermetropia, and so will need reading glasses comparatively early in life and will have to change them frequently for stronger ones. These lenses will always be stronger than those required by the emmetrope at the same age. This frequent change of lenses for stronger ones naturally causes the hypermetrope to fear that at last no spectacles can be found strong enough to correct his defect. But this is not true, for if once the deficient power of the eye shall be entirely made good, the eye is then in the position of the emmetropic eye, and in the future will require only such additions as are usual in the correction of presbyopia.

Manifest hypermetropia is further divided into *facultative*, *relative*, and *absolute*.

In *facultative hypermetropia*, the hypermetropia is overcome by an effort of accommodation and objects can be seen clearly with or without glasses. For example, in childhood and youth with normal accommodation, even a manifest hypermetropia of 3 or 4 D may be unattended with fatigue, but sooner or later after some transient illness, or in consequence of physiological limitations the eyes are no longer equal to the demands made upon them and the hypermetropia becomes relative. In *relative hypermetropia* it is only possible to accommodate for a near point by converging to a point still nearer, or in other words by squinting inward. In relative hypermetropia accommodation and convergence are out of harmony; because there is a desire to focus accurately in order to see distinctly and at the same time a desire to converge accurately upon the object to avoid seeing it doubled. One of two alternative conditions follows, namely, distinct vision with a single eye, the other squinting inward, or binocular vision, but with insufficient accommodation and consequent imperfect vision. In *absolute hypermetropia*, the hypermetropia cannot be overcome by any effort of accommodation or of convergence, therefore distinct vision is impossible. With the advent of absolute hypermetropia the unavailing efforts of accommodation cease and for that reason an internal squint may become less marked or disappear entirely. In youth absolute hypermetropia is rarely seen, except as a sequel of diphtheria. As the power of convergence remains the same, while the range of accommodation diminishes progressively, it follows that in youth the hypermetropia is facultative, in middle age relative, and in old age absolute.

Relation between Accommodation and Convergence.—In considering the importance of accommodation in the production of clear images in hypermetropia nothing has been said of binocular vision and the power of convergence. In binocular vision the images of the two eyes are formed on identical points of the two

retinas and are then fused by the brain into one image. When the eyes fix an object, two different adjustments are necessary, namely, accommodation for the distance of the object and convergence of the axes of the eyes for the same point. In emmetropia these two adjustments correspond exactly, so that with parallel visual lines, the accommodation is completely relaxed and with every degree of convergence a certain effort of accommodation is associated. A convenient method for the numerical denotation of the degree of convergence is in meter angles, as proposed by Nagel. A meter angle (MA) is the angle of convergence required for an eye to fix a point situated at a distance of one meter. In Fig. 3350 the angle of convergence is the angle through which the eye has to be rotated from a position of parallelism in order to fix a point. This method has the advantage of corresponding to similar terms used in measuring the accommodation. Thus if the eyes are fixed on an object fifty centimeters distance 2 D of accommodation and 2 M A of convergence are required for binocular vision. A convergence of 20 M A, which is about the limit in health, enables the eyes to be directed toward an object at a distance of fifty centimeters. According to Landolt, convergence can only be maintained with comfort for any length of time if only about one-third of the possible number of M A is made use of.

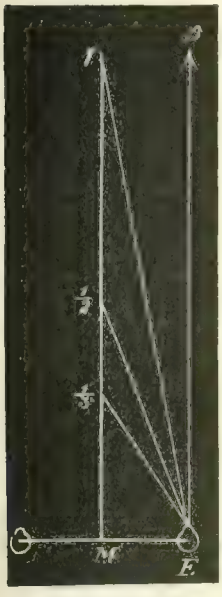


Fig. 3350.—The Angle of Convergence, *EIM*. (Swanzy.)

In hypermetropia the harmony of relation between accommodation and convergence is disturbed and we find that one meter-angle of convergence calls for one dioptric of accommodation plus the amount of accommodation required to neutralize the hypermetropia. In other words, for any given amount of convergence, a stronger effort of accommodation is necessary for distinct vision and *vice versa*, any given amount of accommodation calls for a weaker effort of convergence. While there is a close relation between convergence of the visual lines and accommodation, yet this relation is not absolute. It is easy to prove that accommodation may be increased or decreased, while the object is seen distinctly without change of convergence. If weak concave glasses are placed before the eyes the accommodation is increased, if weak convex glasses are used, the accommodation is lessened, and in both instances the object is seen distinctly while the convergence remains unchanged. With equal ease it can be shown that the convergence may be altered, while the accommodation remains unchanged. If a weak prism with its base turned inward or outward is held in front of one eye, the object can be seen distinctly with both eyes, notwithstanding the altered convergence. There is, however, a limit to these varying adjustments of accommodation and convergence.

The amplitude of accommodation may be *absolute*, *binocular*, or *relative*. The absolute is the accommodation from the far point to the near point for each eye. Binocular is the accommodation from the far to the near point for both eyes at once. Relative is the degree in which accommodation is independent of convergence and is found by the strongest convex and strongest concave glasses with which the object can still be distinctly seen for a given point of convergence. That part which is already in use is termed *negative* and is represented by the convex lens; the part not in use is the *positive* part and is represented by the concave lens. A considerable surplus of the positive part of the relative amplitude of accommodation is essential for sustained accommodation at any distance. The maximum of accommodation (absolute A) is attained only when the convergence is exerted to the utmost and in hypermetropia is developed only in conjunction with an internal squint. As every act of convergence calls for a greater exercise of accommodation, in binocular vision the *relative* accommodation is always less than the *absolute*.

The following table shows the relation of range of accommodation to age.

10 years	Refractive power	14 D	Near point	7 cm.
15 years	Refractive power	12	Near point	8.3 cm.
20 years	Refractive power	10	Near point	10 cm.
25 years	Refractive power	8.5	Near point	12 cm.
30 years	Refractive power	7	Near point	14 cm.
35 years	Refractive power	5.5	Near point	18 cm.
40 years	Refractive power	4.5	Near point	22 cm.
45 years	Refractive power	3.5	Near point	28 cm.
50 years	Refractive power	2.5	Near point	40 cm.
55 years	Refractive power	1.75	Near point	45 cm.
60 years	Refractive power	1.00	Near point	100 cm.
65 years	Refractive power	0.75	Near point	133 cm.
70 years	Refractive power	0.25	Near point	400 cm.
75 years	Refractive power	0	Near point	∞

Etiology of Hypermetropia. Hypermetropia may be due to: 1. A shortening of the anteroposterior axis of the eyeball (axial hypermetropia). This is the most common cause. 2. Diminished convexity of the refracting surfaces of the eye (curvature hypermetropia). This may be due to a flattening of the cornea, the result of scars, or to a flattening of the lens the result of senile changes. In advanced age the refractive power of the lens becomes diminished so that the hypermetropic eye becomes more hypermetropic, the emmetropic eye becomes slightly hypermetropic, and the myopic eye less myopic. 3. Diminution in the index of refraction of the transparent media of the eye. 4. Absence of the crystalline lens (aphakial hypermetropia). 5. Protusion or detachment of the retina, the result of exudation or of a tumor.

In the incipient stage of senile cataract owing to swelling of the crystalline lens a shortening of its focus is frequently observed. Hypermetropia may thus pass into emmetropia or even into such a degree of myopia as to admit of reading without the aid of glasses. This so-called "second sight" is, however, only temporary and vision fails as the cataract develops. A case is reported by Landoldt in which hypermetropia was produced by too great refractive index in the vitreous. A woman with diabetes had at the same time a moderate hypermetropia that disappeared when the sugar disappeared and returned with the return of sugar. The explanation was that while sugar was present, the vitreous became sugary, and its refractive power was increased.

The most common cause of hypermetropia is a shortening of the anteroposterior diameter of the eyeball. The following table taken from Nettleship shows the amount of shortening for each diopter of hypermetropia.

Hypermetropia of	1 D represents a shortening of 0.3 mm.
Hypermetropia of	2 D represents a shortening of 0.5 mm.
Hypermetropia of	3 D represents a shortening of 1.0 mm.
Hypermetropia of	5 D represents a shortening of 1.5 mm.
Hypermetropia of	6 D represents a shortening of 2.0 mm.
Hypermetropia of	9 D represents a shortening of 3.0 mm.
Hypermetropia of	12 D represents a shortening of 4.0 mm.
Hypermetropia of	18 D represents a shortening of 6.0 mm.

Hypermetropia is by far the most frequent form of ametropia. Almost all new-born babies are hypermetropic; with the growth of the child the eyeball may elongate and become less hypermetropic, emmetropic, or even myopic. As a rule hypermetropia

remains stationary after childhood. Hypermetropia is due to an imperfect development of the eyeball, is congenital and often hereditary, especially its higher grades. If one of the parents is hypermetropic we are apt to find the same anomaly in one or more of the children. While slight degrees of hypermetropia are very common, high grades are much rarer than are high grades of myopia.

Anatomical Peculiarities of the Hypermetropic Eye.—The eye is smaller in all its diameters than the emmetropic eye, but especially so in that of the visual axis. The sclerotic near the cornea has a flat, slightly

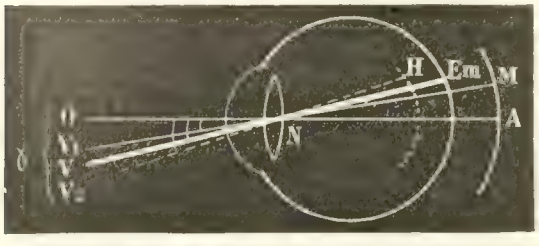


Fig. 3351.—Angle Gamma (γ); in emmetropia (*Em*), myopia (*M*), and hypermetropia (*H*). (Swanzy.)

curved appearance; if the eye is turned strongly inward and the lids separated, the eyeball in the region of the equator is seen to make a sharp curve backward. The anterior chamber is shallow, the pupil is small and the center of motion of the eyeball is displaced slightly backward. Frequently an apparent divergent strabismus is observed due to the fact that the visual line is often very much displaced to the inner side of the cornea, owing to a large angle gamma. In Fig. 3351 is shown the angle gamma formed between the visual and the optic axis. The

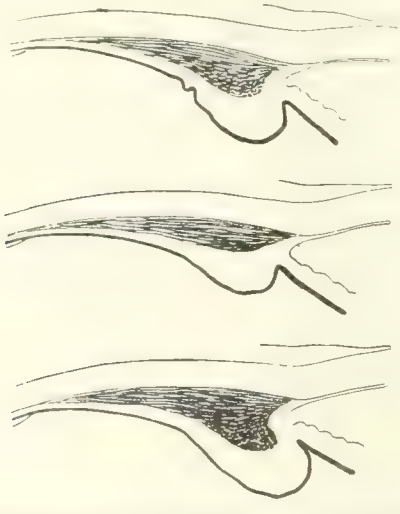


Fig. 3352.—Comparative Size of the Ciliary Muscle in Varying Conditions. *A*, An emmetropic eye; *B*, a myopic eye; *C*, a hypermetropic eye. (After Fuchs.)

size of this angle depends upon the position of the yellow spot in reference to the axis of the cornea. In the hypermetropic eye, owing to the shortness of the eyeball and to an anatomical peculiarity, the distance between the yellow spot and the optic axis is increased which accounts for the larger angle gamma. In myopia, on the other hand, the angle gamma is quite small so that there is often an apparent convergent strabismus. When in doubt as to whether the strabismus is real or only apparent, the following experiment will disclose the true condition. Have the patient fix his gaze on an object two feet distant, then cover one of his eyes with the hand or a card. If the covered eye makes a movement inward or outward to fix the object as soon as the hand or card is withdrawn, the squint is real; if no movement follows the uncovering of the eye, the squint is only apparent.

In hypermetropia the ciliary muscle is increased in size, especially its circular fibers, due to excessive use in accommodating for both near and distant objects. In Fig. 3352 is shown the comparative size of the ciliary muscle in emmetropia, myopia and hypermetropia. In the extreme degrees of hypermetropia, termed *microphthalmus*, the eyeball as a whole is abnormally small, the diameter of the cornea is much less than is usual, the visual acuity is greatly diminished and there may be a coloboma of the choroid and other signs of disordered development. Finally, the existence of hypermetropia is not infrequently indicated in the form of the face. The eyes are apt to be set far apart, the eyelids flat and broad, the orbits shallow with flattened margins, the nose but slightly prominent and the face as a whole, flattened. As a rule, however, peculiarities of physiognomy are not sufficiently marked to attract attention.

Vision in Hypermetropia.—In moderate degrees of hypermetropia the visual acuity is normal, but in high degrees it is very apt to be found diminished even with the proper correcting glasses. This lowered visual acuity is partly due to high degrees of astigmatism to which the hypermetropic eye is peculiarly liable, and partly due to the imperfect development of the eye. The optic nerve is abnormally small, has fewer fibers, and the expansion of the retina is less. The retinal images are also smaller than in emmetropia, notwithstanding the use of strong convex glasses. When a high degree of hypermetropia is confined to one eye, that eye is but little used and soon becomes amblyopic. The same is true of the squinting eye in internal strabismus, a special tendency to which exists in hypermetropia.

The most important difference in the vision of hypermetropes is not the defective sight but the abnormal call upon the power of accommodation. The emmetrope relaxes the muscle of accommodation as much as possible in looking at an infinite distance; convergence and accommodation work in harmony and without strain. On the other hand the hypermetrope must bring his power of accommodation into action in order to see at a distance. Starting with this deficit, he has still for each act of convergence to add as much range of accommodation as the emmetropic person. He is forced by necessity to the constant use of a greater effort of accommodation than of convergence, and finally this increased tension becomes a habit. With each visual act there is a nearer approach to the maximum of possible tension and both the absolute and binocular nearest point lie farther from the eye than they do in the emmetrope. In the facultative hypermetropia of youth the eyes may perform their daily task without symptoms of distress despite this abnormal tension. But with the lapse of years the absolute range of accommodation diminishes and the relative, for a definite convergence, falls short. The eyes are now easily fatigued and premature presbyopia occurs. In relative hypermetropia the difficulty is increased. Accommodation for parallel and even diverging rays is possible but only on condition that the eyes converge to a point, situated nearer than that to which the rays proceed. It is, therefore, impossible to have acute vision and binocular vision at the same time; such attempts are followed by periodical, and later, persistent strabismus. Relative hypermetropia is unusual in children, but frequently occurs after the

twenty-fifth year. Vision in these cases is never distinct for distant or for near objects and the extra effort to attain it is rapidly followed by fatigue. Such persons often hold the book quite close to the eyes in an effort to see well; they knit the brows, half close the lids, and seek a bright light in order to contract the pupils and lessen the circles of diffusion. In *absolute* as well as in the higher degrees of relative hypermetropia, small print cannot be read at all and larger type must be held very close to the eyes in order to be seen. The reason printed matter can be seen near the eye more easily than at some distance is because the retinal image increases in magnitude more than the circles of diffusion.

Symptoms of Hypermetropia.—In hypermetropia there is usually distinct vision for distance, but difficulty in maintaining clear vision for reading or other close work for any considerable length of time. This disability is more marked if the reading is done by artificial light or in a gloomy place. In many cases hypermetropia presents no symptoms whatever. In childhood and vigorous youth if the hypermetropia is of moderate degree (1 to 3 D) the extra amount of accommodation used in the focussing of distant and near objects may cause no inconvenience or fatigue. In other cases and especially after an illness or the close application of school life the eyes are not equal to the demands made upon them and symptoms of accommodative asthenopia develop. In reading vision may be clear for a short time but presently the print becomes blurred and a feeling of fatigue and tension comes on in and especially above the eyes. After rubbing the eyes and resting them for a few moments, the print is once more seen distinctly and the work may be resumed, but only for a shorter time than before. If the effort is persisted in, the symptoms of eyestrain, headache, tension and pain progressively increase until the accommodation becomes exhausted and the work must be laid aside. The patient now finds that at first even distant vision is blurred, and is obliged to give the eyes a prolonged rest. As a rule, the higher the degree of H, the earlier the symptoms of asthenopia appear. As long as the eyes are not fixed on near objects, vision appears normal and the eyes are entirely free from any unpleasant symptoms.

Hypermetropia frequently gives rise to *spasm* of the *accommodation*, especially in children who hold their work too close to the eyes. In such cases the excessive tension of accommodation may even be so great as to cause parallel rays to focus in front of the retina and make the eye apparently myopic. One should be on guard against spasm of the accommodation, otherwise concave glasses might be prescribed, aggravating instead of relieving the symptoms. In childhood, one of the earliest symptoms of hypermetropia is *convergent strabismus*. Impelled by the strong desire to see distinctly the child learns to force his accommodation by a powerful impulse of convergence and thus acquires the power of sustained application by sacrificing binocular vision and laying the foundation of a convergent squint. As stated before hypermetropes sometimes have the habit of half closing the lids and holding a book quite near to the eyes so that the family and friends think they are near-sighted. As a result of the eyestrain in hypermetropia, conjunctivitis, blepharitis, styes, congestion of the choroid and retina, headache, and various reflex nervous symptoms are frequently observed. The hypermetrope is predisposed to glaucoma.

Determination of Hypermetropia.—In the diagnosis and measurement of hypermetropia both *subjective* and *objective* methods are employed. The subjective method consists in finding the strongest convex glass which gives the best visual acuity in looking at test-types placed at a distance of five or six meters. The objective method consists in estimating the amount of the hypermetropia by means of retinoscopy (shadow test) and with the ophthalmoscope. The examination is begun by the subjective method, the visual acuity is noted and the manifest hypermetropia estimated. The total hypermetropia is ascertained after the ciliary muscle is paralyzed by the use of a cycloplegic. The examination is continued in the dark room using both objective methods, *i.e.* retinoscopy and the ophthalmoscope. The objective methods, especially retinoscopy, are of great value in estimating the refraction of young children and illiterate persons. Finally the examination is concluded by a return to the subjective method, when the findings of the dark room are checked up with the best vision attained with the test-types.

Measurement of Hypermetropia with Test-types and Trial-lenses.—The card of test letters is hung upon the opposite wall in a good light (day light or artificial light) and at a distance of five or six meters from the patient. Rays of light are practically parallel at this distance. A trial frame is placed before the patient's eyes, and one eye covered with an opaque disc. Testing one eye at a time the patient is directed to read the smallest letters on the card which he can see distinctly. He may hesitate, but if given sufficient time will eventually read them all. If vision is shown by this test to be of normal acuteness ($\frac{5}{5}$ or $\frac{6}{6}$) myopia and any considerable degree of astigmatism are both excluded. The manifest hypermetropia is measured by finding the strongest convex glass with which the patient can read $\frac{5}{5}$. To encourage relaxation of the ciliary muscle it is a good plan to begin by placing before the eye a convex lens stronger than the one required and gradually weaken it by holding in front of it concave glasses of increasing strength until the maximum vision is attained. The manifest hypermetropia is then the difference between the two glasses. For example, if plus 4 D is placed in the spectacle frame, and minus 2 D held in front of it is the weakest concave glass with which full visual acuity is attained, then plus 4 D plus minus 2 D equals plus 2 D and plus 2 D is the measure of the manifest hypermetropia. If there is reason to suspect spasm of accommodation stronger glasses may often be accepted by testing both eyes together and also by placing a prism of 2 or 3 (centrads) before one eye with its base inward. By thus rendering the axes of the eyes parallel and by relaxing the internal recti muscles, the accommodation is indirectly affected.

The total hypermetropia is estimated after the muscle of accommodation is paralyzed by the use of a cycloplegic; atropine one per cent.; scopolamine one-tenth per cent.; or most frequently, homatropine two to three per cent. It will now be found that a much stronger glass will be required to enable the patient to read $\frac{5}{5}$. This glass represents the *total* hypermetropia and the difference between the total and the manifest equals the latent hypermetropia.

Objective Tests.—1. *Retinoscopy* or the *Shadow Test.* This is a method of estimating the refraction, by reflecting light into the eye by means of a mirror (usually a plane mirror) and observing the direction in which the light or its shadow appears to move across the pupil when the mirror is rotated. The observer sits at a distance of one meter from the patient and looking through the sight-hole of a *plane* mirror, reflects light into the eye from a lamp placed near the mirror and covered with an opaque chimney having an aperture five to eight millimeters in diameter. On slightly rotating or tilting the mirror a shadow is seen to pass more or less rapidly across the illuminated area of the pupil. A bright reflex and a rapidly moving shadow denote a low degree of refractive error, while a dim reflex and a slowly moving shadow denote a high degree of error. If the shadow moves in the same direction as the rotation of the mirror, "*with the mirror*," the eye is hypermetropic; if the shadow moves in the opposite direction to the

movement of the mirror "*against the mirror*," the eye is myopic. When the shadow moves "with the mirror," a weak convex glass plus 0.50 is placed in the trial frame which the patient is wearing and the mirror rotated first on its vertical and then on its horizontal axis. If plus 0.50 sph. causes the shadow to be reversed, move "against the mirror," there is probably a slight degree of myopia; if plus 1 D reverses the shadow, emmetropia is present; any stronger lens than this indicates hypermetropia. Stronger and stronger convex glasses are then placed in the trial frame until the shadow which moved with the mirror disappears and is replaced by a shadow which moves "against the mirror." This is the point of reversal and if plus 1 D is deducted from this glass we will have the measure of the hypermetropia. For example, suppose the point of reversal is found with a 4 D convex lens; 1 D of the strength of the lens was used in making the rays convergent while the other

FIG. 3353.—Rays Emerging from a Hypermetropic Eye. (De Schweinitz, Diseases of the Eye, W. B. Saunders Co.)

3 D have been used to render parallel the diverging rays coming from the eye, hence 3 D represents the amount of the hypermetropia. (See Fig. 3353.) In practice, therefore, we deduct 1 D from the strongest convex lens with which we still get a faint movement of the shadow with the mirror.

2. *The Ophthalmoscope.—With the mirror at a short distance* (two feet) from the patient, an erect image of the disc is seen, which moves in the same direction as the movement of the mirror.

Indirect Method.—If the object lens is gradually withdrawn from the eye, the optic disc will appear to diminish in size.

Direct Method.—In order to measure the amount of the hypermetropia with any degree of accuracy by this method it is necessary that the accommodation of the patient and of the observer be fully relaxed. This is accomplished for the patient by directing him to gaze into vacancy across the dark room and to make no effort to recognize anything sharply. The ability of the observer to fully relax his accommodation at will comes only after long practice. The observer must also be emmetropic or rendered so by using the proper correcting glass in the form either of spectacles or of a lens placed behind the sight hole of the ophthalmoscope and should approach as close as possible to the eye under observation. In measuring the refraction we use as points of observation the smaller retinal vessels in the neighborhood of the fovea centralis. Under ophthalmoscopic examination in a dark room the accommodation is generally found to be so completely relaxed that the measurements obtained may be accepted as a close approximation to the total hypermetropia. The measure of the hypermetropia is then the strongest convex lens placed behind the ophthalmoscope through which the observer sees distinctly the details of the fundus. This convex glass in the ophthalmoscope causes the diverging rays from the hypermetropic eye to be brought to a focus on the retina of the observer.

THE TREATMENT OF HYPERMETROPIA.—Having determined the total amount of the hypermetropia one would naturally suppose that the proper treatment would consist in ordering such convex glasses as would cause parallel rays passing through them to converge to a focus on the retina without any effort of the accommodation. By this means we would advance the position of the principal focus of the eye to the actual position of the retina and render the eye emmetropic. But in practice such is not the case. While the eye is under the influence of the cycloplegic distant vision is distinct with the full correction, but after the effects of the drug have disappeared the same glass causes objects to appear blurred. This is because in hypermetropia the ciliary muscle is larger than normal from excessive use, and is unable suddenly to relax itself completely. The hypermetrope, therefore, rejects a full correction as impairing distant vision, and compelling him to work or read at an uncomfortably short distance. He accepts a somewhat weaker glass which can be worn with comfort and which is, at the same time, of sufficient strength to relieve the symptoms of accommodative asthenopia. The glass to be ordered in hypermetropia will depend upon various factors, *i.e.* the age of the patient, the amount of the manifest hypermetropia, and the symptoms complained of. In childhood and youth, with vigorous accommodation, a partial correction will suffice. If very little of the total hypermetropia is manifest, an undercorrection is ordered and the strength of the glass increased from time to time as symptoms of fatigue manifest themselves. There is a difference of opinion as to the amount of the total hypermetropia to be corrected. A few surgeons give the full correction deducting 0.25 D from the total for the reason that rays coming from a distance of six meters are not strictly speaking parallel, so that the glass which gives 6/6 vision at that distance is an overcorrection of ¼ D. Some surgeons make a rule of deducting 1 D from the total, others correct the manifest hypermetropia only. A good rule is the one advised by Donders—correct the manifest and one-fourth of the latent hypermetropia. For example, the manifest hypermetropia is 2 D, the total is 4 D, therefore, the latent is 2 D. Adding one-fourth of the latent (0.50 D) to the manifest (2 D) would give 2.50 D as the glass to be ordered. When there are symptoms of asthenopia, headache, eyestrain, weakness or spasm of the accommodation, blepharitis or reflex nervous symptoms a glass should be ordered that approximates the total hypermetropia. When there is a tendency to excessive convergence or an actual convergent squint, the total correction less 0.50 D should be worn constantly. The effect of this treatment is to do away with the cause of the squint, to diminish the degree of the deviation, and in recent cases to cause its immediate disappearance. If the squint has existed for some time the correcting lenses must be worn constantly for several years before resorting to operation. If a tenotomy is done at once and the correcting lenses ordered afterward, an external squint is apt to develop in the course of a few years. On the other hand, if weakness of convergence is present, an undercorrection is desirable in order to stimulate the accommodation and with it the convergence.

In the treatment of hypermetropia, whether a glass shall be worn at all, be worn for close work, or be worn constantly will depend upon the symptoms and the character of the patient's work. Glasses will be unnecessary if distant vision is normal and close work is unattended by fatigue. The objection to wearing glasses constantly is that if the hypermetrope accustoms himself to their use, he will gradually lose the power of distinct vision without glasses, because the muscle of accommodation is not sufficiently exercised. Consequently in young persons when the hypermetropia does not exceed 2 or 3 D glasses will be required for reading only. When, however, they have become somewhat older and facultative H has given place to relatively absolute, glasses should be worn for distance also. On the other hand, if distant vision is improved

by glasses, then spectacles which corrects the manifest hypermetropia may be worn constantly.

APHAKIA (α, priv. φακός, lens) is the name given by Donders to indicate an absence of the crystalline lens in the dioptric system of the eye.

Etiology.—Aphakia is most frequently the result of cataract operations, or of a wound which ruptures its capsule and gives rise to gradual absorption of the lens. Aphakia may also be caused by a dislocation of the lens from injury or as a congenital defect, in which the lens gradually disappears from the plane of the pupil.

Refraction in Aphakia.—In the condition of aphakia we have only one refracting surface, namely, the anterior surface of the cornea, and if its curvature is normal, the eyeball should have a length of 30.58 millimeters in order to bring parallel rays to a focus upon the retina. Since the anteroposterior diameter of the normal eye is only about 22.88 millimeters, aphakia necessarily causes a high degree of hypermetropia, in the emmetropic eye, corresponding to about 11 D. The degree of hypermetropia will be increased if the eye was previously hypermetropic and diminished if the previous refraction has been myopic. Indeed if the pre-existing myopia has been of very high grade the loss of the crystalline lens may render the eye emmetropic.

Symptoms.—Owing to the entire absence of accommodation the aphakial eye either sees distinctly when it is perfectly corrected or indistinctly when it is left uncorrected. The conflict between accommodation and convergence has ceased and there are no symptoms of asthenopia or a tendency to internal strabismus so frequently observed in the ordinary forms of hypermetropia. The *vision* in aphakia is usually imperfect. In very favorable cases after a cataract operation vision may be restored to normal by means of a properly selected convex glass. More usually, however, vision does not reach normal, owing to astigmatism and to a slight loss of transparency of the media.

Diagnosis.—The diagnosis of aphakia is made by a search for the reflected images of Purkinje. If a lighted candle is held in front of and a little to one side of a normal eye, three reflected images of the light are seen, one erect on the cornea, one erect on the anterior surface of the lens, and an inverted image on the posterior surface of the lens. If the lighted candle is moved slightly, the erect images move with the light and the inverted image moves in the opposite direction. In aphakia the two reflected images of the lens are absent. Moreover, by means of focal illumination and with the aid of a magnifying glass the sectors and striæ of the lens are easily seen; if these are absent we may infer the existence of aphakia. Finally, the strength of the convex lens necessary to restore distinct vision taken in conjunction with the form of the eye and the entire absence of accommodation will render the diagnosis certain.

Treatment.—The deficiency in refractive power occasioned by the absence of the lens will necessitate the wearing of a strong convex lens, its strength depending upon the previous refraction of the eye. Under ordinary circumstances a lens of about 10 D is required to bring parallel rays to a focus on the retina. As there is an entire loss of accommodation stronger lenses will be required for reading and close work. The usual distance for reading being thirty-three centimeters, a lens having a focal distance of thirty-three centimeters (plus 3 D) is added to the distance glass (plus 10 D plus 3 D equals plus 13 D) and the resulting plus 13 D will enable the eye to read at thirteen inches.

The effect of the correcting glass in aphakia is to advance the position of the nodal point of the combined dioptric system, and thus to give a larger retinal image than in the normal eye; and the farther the correcting glass is placed from the eye the greater is the enlargement. In the ordinary position, the glass is about half an inch from the eye, and the spectacles can easily descend an inch farther on the nose. Hence a sort of artificial accommodation may be obtained by moving the spectacles nearer or farther from the eyes, thereby changing the position of the reading distance.

It is the usual custom to give two pairs of spectacles, one for reading and the other for distance. In unilocular aphakia so long as the fellow eye retains satisfactory vision, it is not advisable to correct the aphakial eye because the dissimilar retinal images confuse the patient. Notwithstanding the imperfect definition of its retinal image, an aphakial eye, though uncorrected, may take part in binocular and periscopic vision and aid in maintaining the normal binocular field of vision.

HISTORICAL NOTES.—While myopia was recognized and studied for centuries the first accurate description of hypermetropia was given by James Ware in 1812. His paper entitled "observations relative to the near and distant sight of different persons" was published in the Philosophical Transactions of the Royal Society of London. After speaking of the senile changes of the eye he said: "There are also instances of young persons who have so disproportionate a convexity of the cornea or crystalline or of both to the distance of these parts from the retina, that a glass of considerable convexity is required to enable them to see distinctly, not only near objects, but also those that are distant, and it is remarkable that the same glass will enable many such persons to see both near and distant objects; thus proving that the defect in their sight is occasioned solely by too small a convexity in one of the parts above mentioned, and that it does not influence the power by which their eyes are adapted to see at distances variously remote. In this respect such persons differ from those who had the crystalline humor removed by an operation; since the latter always require a glass to enable them to discern distant objects different from that which they use to see those that are near." In these remarkable words, James Ware, the English surgeon, earns the credit of having discovered hypermetropia. The value of Ware's observations were not recognized at the time, and not for almost half a century afterward. In 1845 Sichel sketches a distinct picture of high degrees of hypermetropia, to which he gives the name of *amblyopie presbytique congénitale.* He did not, however, comprehend the nature of the affection and although he states that convex glasses improve vision, he would never allow his patients to wear them, declaring that they must in the end cause a total loss of sight. Even as late as 1853 this singular prejudice against the use of convex glasses for distance continued. Mackenzie in his text-book speaking of the prognosis of asthenopia now known to be caused by hypermetropia says: "It is our duty to declare the disease incurable," and advises change of occupation and emigration, stating that though they never could employ their eyes advantageously where much reading or writing was required, they might see sufficiently to follow the pastoral pursuits of an Australian colonist." Mackenzie also reports the following case: "A child, the subject of asthenopia, engaged in learning his lesson, complains he cannot see, and repeats the complaint so frequently, especially by candle light, that his father or grandfather at last says: 'Try my glasses.' *The child now sees perfectly,* and night after night the loan of the glasses is required before his task can be finished." And yet, he adds, "It would have been better had glasses been selected of the longest focus which would have enabled the child to read or, better still, he had been put to bed, and the lessons left till daylight." In 1853 Ruete describes hypermetropia under the name of oversightedness (uebersichtigkeit),

but incorrectly supposes that the power of accommodation is in these eyes almost wholly wanting. In 1855 Stellwag in an essay on accommodation speaks of hypermetropia as hyperpresbyopia.

Finally, in 1860, Donders published the first accurate description of hypermetropia and suggested the name which it now bears. The present article is largely drawn from his remarkable work "On the anomalies of Accommodation and Refraction of the Eye," the new Sydenham Society, London, 1864, in which he treats the subject so exhaustively that since his time nothing of importance has been added to our knowledge of the subject. J. Ellis Jennings.

Hypernephroma.—By this term (from ὑπέρ, above, νέφρος, kidney, and ωμα, signifying a growth) is understood a tumor composed of hypernephroid or adrenal tissue.

The discovery of what appear to be adrenal rests, especially in the kidney, and the possibility that these may give rise to malignant neoplasms, have opened wide the door of speculation. We do not know to what extent the embryonic misplacement of tissue of various organs may be responsible for the development of abnormal growths. At any rate, the presence of adrenal rests in the kidney is now pretty generally recognized as the origin of the hypernephromata, the most frequent class of malignant growths found in the kidney.

Von Bergmann describes hypernephroma as a nodular tumor of yellowish or brownish color with a harder center and a softer periphery which either presses aside the neighboring tissue or infiltrates it, and destroys it by the formation of new nodules. The mass of the tumor is made up of connective-tissue stroma, whose meshes are filled by cubical or polygonal cells containing fat or glycogen. In the older portion of the tumor there may be cysts of degeneration and hemorrhagic areas.

I. W. Blackburn, declares that we have in hypernephroma a potentially malignant tumor derived from aberrant or normal adrenal epithelium, which is of mesoblastic derivation and which cannot be grouped with either of the two great classes of malignant growths, carcinomata or sarcomata; although at present we have to acknowledge that carcinoma may be derived from all three layers of the blastoderm, yet this tumor differs in important details from the carcinomata, and the resemblance to ordinary sarcomata is still more remote.

Hypernephroma, the struma lipomatodes aberrata renis of Grawitz, is the most frequent of the tumors that occur as primary growths in the kidney. Whereas the number of reported cases of sarcoma and carcinoma of the kidney is decreasing, there has been a notable increase in the hypernephromata. It has been held that these tumors originate from particles of fetal tissue intended to develop into adrenal bodies but which have become enclosed in the renal anlage. At any rate particles resembling adrenal tissue are often observed in the kidney, usually just beneath the capsule, and from these tumors not infrequently develop. Such tumors vary greatly in their rapidity of growth, sometimes appearing larger from week to week and again requiring a number of years for their development. Metastases may occur through both the blood and lymph, but chiefly through the venous channels. The tendency to spread by continuity or contiguity is not marked. In many of the reported cases metastases caused death through general infection while the growth in the kidney was small in size. In other cases the tumor has attained considerable size with few or no metastases.

Grawitz held that hypernephromata developed from supernumerary adrenals, since these tumors show a somewhat similar microscopic appearance to the zona fasciculata of the adrenals (*Virchow's Archiv*, Bd. xciii., 1883; *Berl. klin. Woch.*, 1884). Objection to this view is founded partly upon the observation that hypernephromata are rare in the adrenals. Furthermore the so-called adrenal rests are most frequent in the upper pole of the kidney, whereas hypernephromata are more common in the lower pole. Similar islets of adrenal tissue occur in the liver, where hypernephromata have not been found. It is altogether probable that many cases reported as hypernephromata are really carcinomata arising from the epithelium of the renal tubules.

Hypernephromata are most common in middle life but have been reported at both extremes. There seems to be a slight preference for the male sex and the right kidney.

Secondary infection of the opposite kidney is not infrequent, probably due to the fact that mestastasis in these cases is specially prone to follow the venous routes.

Adrenal rests are found most frequently in the kidney but may occur in various other organs, notably the ovary, testicle, spermatic cord, liver, and pancreas. Hall was able to find such remnants but once in 2,000 postmortem examinations. They are usually located in the region of Bertin's columns (Lubarsch). Recent investigations place the hypernephromata among the mesotheliomata. The adrenal rests usually vary in size from a split pea to a walnut; the hypernephromata may attain the size of an adult head or larger. They show a tendency to grow into the veins as soft friable masses, which Weiler has observed may extend even up to the right auricle. Metastases occur especially in the lungs, liver, and bones, less often in the brain and opposite kidney. It would seem that they may occur almost anywhere in the body.

Dunn, in eighty consecutive postmortem examinations, found suprarenal rests, adenopapillary tissue, and papilliferous cysts fairly frequently, and of these he believes the last named, from their peculiar histological features, are the most probable origin of tumors of the Grawitz type.

Hypernephroma of the adrenal may lead to various developmental anomalies. Precocious obesity may assume prominence. Adrenal hypernephroma in the female may be associated with male secondary sex characters. Glynn and Hewetson studied adrenal hypernephroma in its relation to sex characters and summarized their observations as follows: 1. In children they are almost invariably present in the form of hirsuties and often other abnormalities (seventeen cases of hypernephroma collected; in sixteen, namely, thirteen females and three males, sex abnorabnormalities were present). 2. In women before the menopause they are frequently present (twelve cases collected; sex abnormalities present in seven, while in two others menstrual disturbance occurred before death). 3. In women after the menopause they are not recorded, though a growth of hair on the face or change in the voice, etc., might be thought worthy of note (eight cases collected). 4. In men they are probably invariably absent. In this connection it is of great interest that adrenal cortical rests or bilateral hyperplasia of the adrenal cortex were noted in fifteen per cent. of female pseudohermaphrodites, but in only 0.7 per cent. of male pseudohermaphrodites. 5. There is no evidence that hypernephroma in the kidney, which has a totally different histological structure from that in the adrenal, is ever associated with abnormal sex characters.

Symptoms.—The symptoms of renal hypernephroma are more or less vague. Usually there is pain in the region of the kidney and more or less of the dragging sensation so common in nephroptosis. With the growth of the tumor, pressure symptoms assume prominence, such as edema of the lower extremities and venous congestion, which may present a caput medusæ or an enlargement of the spermatic veins.

Pain in or near the kidney, often radiating to a considerable distance, is a fairly constant symptom. Thus Mayo Robson observed a case in which the pain was most severe in the shoulder. The pain may be due to the pressure and weight of the growth, or to the passage of blood clots or casts of the renal pelvis or ureter. In the former cases there is pain, usually dull in character, with the dragging sensation so common in nephroptosis; in the latter instances, there is renal colic, similar to that observed in the passage of a calculus.

The gross appearance of blood (hematuria) is not the rule, probably because the growth usually begins near the capsule. With the encroachment of the growth upon the renal pelvis, hemorrhage is more likely to occur. In some cases, hematuria is the first sign of hypernephroma, appearing sometimes long before the patient complains of pain or other discomfort.

Metastases may occur in various parts of the body. The location of the metastases is not of much value in diagnosis, because they show such great variations in the reported cases. They occur especially in the lungs, liver, bones, and in or near the line of incision, should the growth be incised.

Diagnosis.—As is so often true in the diagnosis of tumors, frequently an exact histological diagnosis cannot be made save by a microscopic examination of the growth. In early life these growths are to be differentiated especially from sarcoma, and in later life they should be separated from carcinomata. At all times, renal tuberculosis and calculus must be considered in diagnosis.

The clinical diagnosis is not easy as a rule when the tumors are small in size and of slow growth. Hematuria may occur early in renal tumors, especially when they involve the pelvis of the kidney. Hypernephroma usually originates in the cortex, near the capsule. When the tumor has increased sufficiently in size to enlarge or deform the kidney, radiography may aid in diagnosis and is of especial value in cases presenting thick abdominal walls through which the kidney may not be readily palpated. Usually palpation reveals the kidney enlarged and deformed. The growth is fixed, posterior to the intestine, and often shows some tendency to bulge posteriorly. It is more firm than a cystic kidney.

Renal calculus may present hemorrhage as an initial symptom. Pain may be absent but is usually present. The stone, especially if large, may not become impacted in the ureter to produce the colic so often present in nephrolithiasis.

Tuberculosis may be primary in the kidney and for a time present hemorrhage as its only symptom.

The malignant neoplasms of the kidney, including the hypernephromata, may exist for a number of months without causing pain, to reveal their presence first by hemorrhage.

In hypernephroma the correct diagnosis is suggested as a rule by the absence of the usual signs of calculus or tuberculosis of the kidney and the absence of pus irritating the neck of the bladder. The renal neoplasms may cause hemorrhage, so that the examination of the interior of the bladder will show a blood clot protruding from the ureter, but there will be no eroded zone around the ureter such as may be observed when there is an irritating discharge from the pelvis of the kidney.

Palpation and percussion show increased dulness only when the growth has attained considerable size. There are marked anemia and general debility. Leucocytosis is rarely over 12,000, with a diminution of the hemoglobin. In many cases high blood pressure has been noted. Pigmentation of the skin, so common in tuberculosis of the adrenals, is rare in hepatic hypernephromata. Saalmann has reported a case of Recklinghausen's disease with hypernephroma, which may have been only a coincidence.

Several authors have mentioned varicocele as a complication. Metastases should not be mistaken for enlarged veins.

Differential diagnosis must often take into account tuberculosis, cyst, and neoplasm. Tuberculosis of the kidney usually shows fever and pyuria, and pain less intense and extensive than in hypernephromata. A cyst may attain a large size without causing much or any pain. It has been observed that cysts are more prone to raise the blood pressure. Renal calculus may cause hematuria but does not produce a tumor. Renal pain that is relieved by hematuria is distinctly characteristic of renal neoplasms.

From a clinical standpoint, it is good practice to subject all cases of renal tumor to the Wassermann test, unless we are absolutely sure of our diagnosis.

Treatment.—Whether or not to operate is a question that is often difficult to decide. The individual with but one kidney is not so well able to withstand many of the vicissitudes of life. In many ways the loss of a kidney is a greater defect than the loss of an eye or one of the extremities. Furthermore it is often difficult to make a positive diagnosis of hypernephroma before the development of metastases. In general the greater the loss of renal function on the affected side, the less will be the immediate danger following the removal of the diseased kidney.

Should the other kidney be healthy, the affected kidney should be removed entire and without incising the tumor, as soon as the diagnosis of hypernephroma is made and before metastasis occurs.

Any incision of the tumor may be followed later by a recurrence in the line of the cut.

George E. Malsbary.

Hypertrichosis.—(Greek ὑπέρ, in excess; θρίξ, hair.) *Synonyms:* Hypertrophy of the hair; superfluous hair; hairiness; hirsuties; hypertrichiasis; polytrichia; trichauxis; trichosis hirsuties; (French) poils accidentels.

Hypertrichosis is an excessive growth of hair in relation to length, thickness, region, and age and sex of the subject.

Man of all the primates has the smoothest skin, the only parts that are in general covered thickly with hair being the scalp, axillæ, and pubic region. Males have often in addition a heavy growth on chin, chest, abdomen, and extensor surfaces of the limbs. Hair follicles are present over the entire surface of the skin with the exception of the palms and soles, the dorsal surfaces of the last phalanges of the fingers and toes, the upper eyelids, and the red mucous membranes of lips, vulva, and anus.

The first sign of hair appears at about the third month of intrauterine life. It occurs in the region of mouth, eyebrows and forehead as a downgrowth of cells into the rete. About the sixth month, the hair, having developed, pierces the skin, and the entire fetal integument excepting those regions already named becomes covered with lanugo hair. Before birth the lanugo is shed and new hair growing out of the old follicles replaces the primary growth. In some instances this process is not completed *in utero* but extends into the first few months after birth. All fetal hair is non-medullated. After birth, although a new growth of lanugo hair covers the greater part of the body surface, the scalp, lips, chin, axillæ, and pubes are supplied with medullated hairs. Unlike some animals, human beings have no moulting season. Instead there is a slow continuous shedding of old hairs that are forced out and replaced by a fresh growth. Besides this continuous process there are periods of more active growth. Hair grows quickly on the scalp of the newly born. At puberty the chin, axillæ, and pubes become covered with hair. At middle age and in old age there commonly occurs a

growth of coarse hairs from nostrils, ears, and eyebrows. These hairs are called vibrissæ.

In certain women at the time of the menopause there develops a vigorous growth of hair on various parts, especially on the face. This growth sometimes occurs during pregnancy.

Hypertrichosis may be congenital or acquired; and local or universal. In *congenital* hairiness it is not unusual for infants at birth to exhibit a growth of very long hairs on the parts generally covered with hair. In general such growth is later succeeded by shorter hairs.

Local congenital hairiness is not uncommonly observed, a familiar example being nævus pilosus, or the hairy mole. The hairs may be few or many; light colored or dark; but they are nearly always coarse and long. These moles may occur singly or in numbers, and although they may appear on any part of the skin, the most usual site is the sacral region. Hyde and Montgomery call attention to cases in which extensive regions of the body are the site of large pigmented moles covered with warts, fibromata, and other tumors of benign nature,and having a thick coat of long or short hairs. "All such cases exhibit a striking development in either symmetrically or asymmetrically disposed areas of distribution of cutaneous nerves." Another instance of local congenital hypertrichosis is observed in spina bifida occulta and other abnormalities of the spinal cord. A lock of hair is sometimes seen growing from skin otherwise normal, as for instance that covering the shoulder.

Universal congenital hirsuties is a rare condition. Longer or shorter downy hairs of various colors then cover the entire body. The element of heredity commonly plays an important rôle in such cases. In some of these subjects the body is covered by a marked downy growth which is accentuated in such parts as the axillæ and pubes.

The vortex-like arrangement of the hairs on limbs and back is familiar to dermatologists. The umbilicus and sacrum offer examples of the radial arrangement. In general the face is most affected. The few striking instances of universal congenital hypertrichosis have become a matter of history, having been reported from time to time. Andrian Jeftichjew (the "Russian dog-faced man") and his son Fedor are noted examples of this deformity. They were exhibited in various countries in the latter part of the last century. The face and region of the spinal column were the special sites for the hairy growth, although the general growth was marked. Certain races, among them the Burmese, are specially prone to this anomaly. Perhaps the most noted examples of this race were Shwe-Maon and his daughter Maphoon. Shwe-Maon's entire body and face excepting hands, feet, and the mucous membranes of the lips were covered with light gray hair several inches in length. Maphoon was also covered with hair. Both showed dental anomalies which are commonly associated with hypertrichosis. So are other stigmata of arrested development such as retarded puberty. A daughter of Maphoon was also hairy, the abnormality showing itself without break to the third generation.

In some of these cases there is entire absence of molar or canine teeth. Stricker reports the case of Barbara Urster, who lived in the sixteenth century, and who is said to have had a beard falling to her waist. Perhaps a better known example of general hairiness including a luxuriant beard was Julia Pastrana, a dancer. This woman had a daughter also exhibiting marked hypertrichosis.

The hairy Ainos, inhabitants of the islands of Jesso and Kurile north of Japan, are historical figures, although there appears to be room for doubt as to whether all of these people are thus afflicted. At any rate it is said that the peculiarity is far more marked in the men than in the women. But this greater prevalence in the male is universally true.

Acquired Hypertrichosis.—Freshwater in a recent report on hypertrichosis has collected several interesting instances of the acquired type. An unmarried woman, aged thirty-three, showed general hairiness at the age of puberty. A bald plaque on the vertex of the scalp was the only uncovered spot. This patient suffered from amenorrhea.

A married woman, twenty-three years old, developed general hirsuties after a miscarriage followed by amenorrhea which lasted eleven years. The hypertrichosis was succeeded by general alopecia.

A temporary hypertrichosis sometimes occurs during pregnancy, but disappears after labor.

The same phenomenon has occurred after interruption of the menstrual flow, the hairiness disappearing on reëstablishment of normal conditions. Another case is that of a woman who after bearing several children, passed through a period of prolonged amenorrhea during which time her face became covered with coarse hair. Later she again became pregnant and after the child's birth the hairs disappeared spontaneously.

The acquired form does not compare in severity with the congenital type. But women, nevertheless, suffer keenly from this affliction. To them the growth on the face is peculiarly distressing. Men, too, not infrequently present themselves for the removal of coarse hairs from nostrils, ears, between the eyebrows, and from the backs of the hands.

Heredity is as clearly to be traced in acquired hypertrichosis as in the congenital form. In certain families a degree of hairiness develops in the adults or older members.

In some individuals, tufts or scattered hairs or groups of hairs appear in various parts; in others, a general downy growth becomes marked. The hair of the head sometimes reaches a great length as in the case of the dancer Negreni whose hair grew to more than nine feet in length. Allworthy reports the case of a man whose beard measured ten feet, ten inches in length. These local growths may occur without any trace of general hirsuties. Very rarely premature beards appear on the faces of youths. Even girls have exhibited this disfigurement. Chown, in 1852, reported the case of an eight-year-old boy who had a beard and pubic hair. A more recent case is that of Lesser's, a girl who began to menstruate at the age of three and who had pubic hair at four years of age.

In all instances of hypertrichosis, whether congenital or acquired, the regions normally unprovided with hair follicles are not the site of pilosis.

Plica polonica originally took its name from the supposition that it was a disease peculiar to Poles. It has long been known, however, to be the result of prolonged neglect, filth, parasitic invasion and the sequelæ. In this condition the crown of the head is covered with a matted mass of hairs. The natives of Alaska are sometimes thus afflicted.

Hypertrichosis neurotica is a term applied to an excessive growth of hair which sometimes follows spinal paralysis and other morbid states of the nerve centers. Similar changes may be associated with hyperidrosis, changes in the nails, and extensive tylosis of palms and soles.

Neuropathic plica is that condition in which hairs in "lumps" or "festoons," looped, curled, flat and tangled appear on one part of the scalp in patients who have previously suffered from neuralgia at that site.

In trichiasis certain of the eyelashes are so turned inward as to irritate or injure the conjunctiva.

Distichiasis is the condition in which there is a double row of lashes which are often the source of similar suffering.

Etiology.—Although some of the apparent causative factors have already been alluded to, they will be mentioned again under this heading, together with others. The causes of hypertrichosis are obscure.

The general congenital type seems to be due to transitory arrested development of the normal hairy covering followed by postembryonic growth of fetal lanugo.

Hirsuties may be congenital or acquired. When acquired, the growth may occur during childhood, adolescence, at the age of puberty, in middle life, or in old age.

Racial tendency, heredity and family idiosyncrasy are frequently influential factors.

It is more common in males than in females and in brunettes than in blondes.

A theory concerning hirsuties in women suggests that the daughter inherits to a greater degree the paternal than the maternal characteristics. To strengthen this theory attention is called to the greater prevalence of hirsuties in masculine women. However, this suggestion seems open to question.

The increase of hair at puberty is normal, and during pregnancy it is sometimes marked. The period at which it is most common is that of the menopause and later.

Whatever brings an excess of blood to any part of the body supplied with hair follicles may act as an indirect cause. This would offer an argument against much facial massage. The very common superstition that 'greasy' cosmetics cause the growth of superfluous hair has little weight with most modern dermatologists. The theory that the application of animal fats in particular is responsible for the unwelcome appearance partakes more of fable than fact. It may be added that massage of the scalp even with grease or stimulating lotions often fails to stimulate the hair growth or even stop its falling. In those individuals with a natural tendency to hair growth, hyperemia of the parts, however produced, may be the exciting cause of stimulation. Severe illness is sometimes associated with hair growth on the face. Certain diseases as malignant endocarditis appear to be related to the appearance of superfluous hair. Hypertrichosis is observed in those with congenital deformities of various types, as an epiphenomenon in dwarfs and monsters.

In rare instances irritation of the skin by the persistent application of certain stimulating and oily liniments, sinapisms, or warmth to a region racked by neuralgic pains, has after a long period been followed by an abundant growth of hair on the part. Injury by pressure or otherwise may bring about similar results. The local hyperemia is doubtless the influential factor. The growth at times appears in the vicinity of wounds or ulcers particularly after the use of irritating applications. But in such instances the abnormal crop is apt to fall out after the irritation ceases.

Again, disorders of the nervous system are believed to be the etiological factor. It is not infrequently noted in insane women. Disease of the genito-urinary system whether functional or organic, as in amenorrhea, and in cancer of the suprarenal capsules in either sex, is pointed out as an exciting cause. Hirsuties has occurred in "perverted, precocious, or arrested activity of the sexual function." Baum declares that the majority of cases occur among women living *absque marito*. In two of his cases hairiness developed after interruption of the marital relation and disappeared on its resumption. In another patient the superfluous hair on lip and chin disappeared after marriage and the birth of her first child. Still another rejoiced in the loss of this growth after the correction of dysmenorrhea from acute uterine flexion, and the reëstablishment of normal menstruation. Overworked spinster school teachers furnish this investigator's largest quota of cases. Hypertrichosis is often observed in diabetics. Seborrheids are not uncommonly associated with superfluous hair. The presence of indican in the urine is conspicuous in many of these cases. There is often a scanty growth on the scalp with an exuberant growth on the face. "Just as toxemias destroy hair on the top of the head, where hair ought to grow, so toxemias seem responsible for the overgrowth of hair on the face." And although the convenient term "poils accidentels"—accidental hairs—is often applied since no apparent cause can be determined, and although many patients insist and believe that they are otherwise perfectly normal and in good health, recent students of this anomaly, after searching analysis, have invariably found some departure along the lines previously emphasized.

Prognosis.—The outlook is by no means a happy one for either patient or physician. The growth as a rule is permanent. Spontaneous cure can be expected in only those cases in which the growth has been due to a transitory cause

In women facial superfluous hair tends to increase in length and coarseness, and deepen in color with the passage of time, this luxuriance being most conspicuous at the menopause.

The hair on moles is also permanent in character. Electrolysis is the best form of treatment, since plucking and other irritating measures are not unlikely to result in a malignant growth. Then, too, after the hairs in a mole have been removed by electrolysis, the growth generally shrinks, leaving a slight pigmented spot in place of the original large dark growth.

Treatment.—Recent observations would point to the importance of careful analysis of each case. And although as yet the field of prophylaxis is little explored, if pains were taken to remove all possible causes, and to build up the general health as well as to correct local troubles, many dermatologists are convinced that there would be fewer instances of superfluous hair needing operation.

The aim of treatment is chiefly to destroy the growth or at least to make it as inconspicuous as possible.

The arrest of the growth, only by the indirect means already mentioned, is practically impossible.

Most of the patients who present themselves for treatment are women suffering from the growth on their faces. These patients are extremely sensitive and morbid. Many become so depressed and bitter as to affect both their physical and mental well-being. They feel that they are the objects of ridicule, scorn, and pity. Many become so self-centered that they can think of little else than this distressing deformity. They lose all ambition and interest in life and not infrequently do such individuals express a preference for death rather than life with such a heavy burden.

Although facial hirsuties is the predominant trouble in these patients, there are not a few who are annoyed with the growth on arms, hands, legs, and breast.

Hair on the shins is especially annoying to those who indulge in sea-bathing and likewise to those who are fond of wearing thin stockings.

It is only the physician who has observed the keen suffering of the victims of hypertrichosis who appreciates the importance of the skilful relief of this trouble. Hair on the face in women is a repulsive deformity and justifies the greatest pains on behalf of both patient and physician in its removal. Many methods obtain for the removal of superfluous hair, but most of these are practicable in only those cases in which there is a limited growth.

These methods may be grouped as follows: (1) plucking; (2) cutting, shaving, singeing; (3) pumice-stone; (4) bleaching; (5) depilatories; (6) *x*-rays; (7) Kromayer's method; (8) electrolysis.

1. *Plucking.*—Various authorities advise persistent epilation. This method is commonly employed in the Orient.

Many women use tweezers for this purpose. The transitory effect is discouraging, and besides the later growths are apt to become coarser and coarser.

The savage method of using pitch plasters is not in high favor on account of the pain incident to its employment.

Single hairs may be removed by the resin-pencil suggested by Unna. This instrument slightly softened by heat is attached to a single hair, and by a little jerk on the pencil the hair is forcibly dislodged.

2. *Cutting, Shaving, Singeing.*—Certain authorities advocate cutting the hairs with scissors close to the skin.

Shaving stimulates a stronger growth of hairs but nevertheless is a method advised in special cases. The effects are similar to those of depilatories. But at least shaving will not cause the growth of new hairs. In brunettes after shaving, a tiny area about the separate hairs sometimes darkens in tint. If the patient decides to shave, a safety razor should be used. The frequency of the process will be regulated by individual conditions.

Singeing with the spirit flame or with red hot nutshells (an old-fashioned method) is a substitute for shaving. This when used is generally confined to the removal of hairs from the backs of the hands in men and from the axillæ and legs in women. It may be well to note here that serious cases of infection often occur after the removal of hair from the axillæ.

3. *Pumice-stone.*—Some dermatologists favor the use of a piece of smooth pumice-stone. After the hair is shaved or cut close, the stone is rubbed gently over the surface against the direction of the hair growth. Then a simple emollient is applied to the parts. The periods of treatment, six months each, are interrupted from time to time by an interval of a month. The results of this treatment are disputed. Schwenter-Trachler reports 252 successful cases.

4. *Bleaching.*—Bleaching by hydrogen peroxide is especially in vogue among brunettes. Here again final results seem to vary. As a rule this method is advised in case of down too fine for treatment by electrolysis. Hydrogen peroxide may be used in solution or it may be employed in the form of a cream. First, the parts are washed with hot water and soap and a little ammonia, or with a mixture of ether and spirit, in order to remove the natural oil, thus giving an opportunity for the hydrogen peroxide to have an effect. The solution is then applied to the superfluous hair with a soft cloth. Several applications may be necessary to obtain the desired result. The hydrogen peroxide should at first be diluted with an equal amount of water in order that the effect on the skin may be noted, for in some cases it is irritating, even causing blisters. Certain authorities believe that hydrogen peroxide in time makes the hair brittle, and finally destroys the growth. Others believe that it makes the hairs coarser.

The cream is made of:

Perhydrol	ʒ iss.
Adip. lanæ anhyd	ʒ vi

The cream is far slower in its action but is more convenient to use than the liquid form.

Still another preparation is sodium peroxide soap which is made up in various strengths. It is left on the skin for a few minutes, the period being regulated by the effect. Hair on the arms and legs is conveniently bleached by this method.

5. *Depilatories.*—Depilatories have been well called chemical razors. These preparations originated in the East where they have been used from early days. Probably the oldest depilatory is orpiment or yellow arsenic; this is not in great favor on account of its poisonous character for it contains a large quantity of arsenious acid. When used it is always mixed with quicklime, the special action on the hair being due to the chemical combination of these two ingredients.

Among other substances employed as depilatories are barium sulphide, sodium sulphide and calcium sulphide which is formed when orpiment and lime are mixed. Many formulas are used and the patent medicine vender appreciates the rich harvest that is ever ready for him in this field.

Rhusma turcarum has the following formula.

℞	Orpiment	ʒ ss	2 0
	Calcii hydrat	ʒ ijss	10 0
S. For external application.			

Pleuck's depilatory also contains orpiment:

℞.	Orpiment	gr. xv.	1.0
	Calcariæ ust.	ʒ ijss	10 0
	Amyli	ʒ jss	6 0
	M.		
S. For external application.			

These preparations are rubbed to a soft paste with water and are then applied with a wooden spatula to the affected skin. As soon as the caustic action begins the mass is wiped off and the part washed with warm water; an emollient is then applied followed by a powder. In from two to five minutes the desired result is obtained from the use of orpiment.

Boettger first recognized the depilatory action of sulphides, *i.e.* hydrosulphates of the alkalies and alkaline earths, especially that of calcium sulphide. This must always be freshly made. It is prepared by saturating lime paste with sulphureted hydrogen. This preparation is almost insoluble in water; sodium sulphide on the other hand is easily soluble in water.

Anhydrous barium sulphide is likewise used as a depilatory. Depilatories dissolve the horny substance of the hair into a gelatinous mass which is wiped from the skin. In time the skin as well as the hair would be destroyed leaving an ugly scar. Otherwise the hair root is not affected.

Boettger's depilatory is often employed for finer hair. This preparation is applied in a layer one to two millimeters thick and is allowed to remain from ten to thirty minutes:

℞.	Calc. hyd. sulph. in aqua	ʒvi.	20.0
	Ung. glycerini,		
	Amyli	āā ʒiii	10.0
	Ess. citri	gtt x	

Other depilatories are Debay's:

℞.	Calc. ust.	gr. cxx.	8.0
	Orpiment	gr. xv.	1.0
	Liq. potass.		
	Album. ovi	āā q. s.	
F. pasta mollis.			

Redwood's which must be made fresh for each application on account of its ready decomposition:

℞.	Solut. concentrat. barii sulphidi	ʒi, ʒvj	50 0
	Amyli	q.s. ut f. pasta.	
S. For external application.			

Clasen's:

℞	Barii sulphidi	ʒvj, gr. xxvj.	25 0
	Zinci oxydi,		
	Amyli	āā ʒiij, gr. xij.	āā 12 5
S. For external application.			

Boudet's:

℞.	Sodii sulphidi	gr. xlvi	3 0
	Calcii hydrat.,		
	Amyli	āā ʒijss.	āā 10.0
S. For external application.			

Duhring's:

℞.	Barii sulphidi	ʒiii
	Pulv. zinc. oxyd.,	
	Amyli	āā ʒi.

This last formula is excellent, but it is important that the sulphide be fresh, and the preparation be in the form of impalpable powder which is made into a thin paste with water just before using. Within two weeks after the use of a depilatory the hair begins to be annoying. The patient should be warned to remove the depilatory in a short time and to watch

its effect on the skin in order that no harm may be done.

It will save disappointment if the patient is told in the beginning that the results will be merely temporary, that the hairs will return stronger than ever, and that when once the use of depilatories is begun, it must be continued and at shorter and shorter intervals.

6. *X-rays.*—A few years ago, hopes were high in regard to the results of this method. But they have proved deceptive. The majority of dermatologists now believe that the results are too uncertain and the possibility of injury is too great to risk the treatment. In the early days of the *x*-ray, very serious burns were inflicted. In some cases after this treatment, atrophy of the skin, a parchment-like condition, occurred, in others telangiectasis, in still others cyanosis, and marked pigmentation. "However careful and precise the dosage of *x*-rays, the margin of error is so small that one can never be sure that what is sufficient to produce a permanent epilation will not cause marked changes in the skin which, if occurring on a woman's face, would never be forgiven and might render the operator liable to an action for damages." Thick, disfiguring black growths of beard are even yet sometimes treated by the *x*-ray. But it a patient decides to undergo this treatment, the risks should be made very plain by the physician before the sittings are begun.

7. *Kromayer's Method.*—Kromayer has used and described the punching method of epilation which consists in punching out small discs of skin with a rotary circular knife. "The attachments of the hair follicle to the cutis are fairly close, but the root itself in the subcutaneous tissues is but loosely fixed. The author employs circular cutters varying in diameter from 0.7 to 1.2 millimeters, which are driven by a treadle machine or a motor, and with which it is possible to punch out minute discs of skin, the resulting wound healing without leaving a scar. The method of application is to cut the hairs short and with a quick touch of the cutter to punch out a tiny piece of skin having a hair in its center, the knife being carried just through the cutis. The stump with the root attached may then readily be removed with forceps. The course taken by the knife should follow that of the hair, but usually the instrument need not penetrate to a greater depth than 1.5 millimeters. The pain caused is about the same as that attending the prick of a needle, and for sensitive patients freezing with ethyl chloride is recommended. Depending upon the circumstances, from one to two hundred hairs may be removed at a sitting and the author has gone as high as three hundred." All dermatologists are not so optimistic about this treatment as Kromayer. Some recommend it for rare cases only when there is a condition of isolated thick stubbly hairs. Attention is also called to the disadvantage of the cumbersome apparatus required and the hemorrhage.

Kromayer's new method of *multiple epilation* is carried out by means of the simultaneous use of five gilt and insulated needles attached to wires. Each needle is introduced into a hair follicle and thus five hairs, instead of one are removed at a time. It is claimed that instead of 50 per cent., only from 10 to 20 per cent. of the removed hairs return to be removed a second time.

8. *Electrolysis.*—Variations in the technique are numerous. Baum has recently described an excellent method. He believes that with patience "it is possible to remove any growth of hair, permanently, without scarring and without pain worth considering." The patient sits in a chair high enough for the operator to work without bending over. A good light is essential, northern exposure being best. The working area is mopped with absolute alcohol. The orifice of the hair follicle is frequently filled with inspissated sebum and epithelial débris. The alcohol softens this mass thus making easy the introduction of the electrode. To a certain extent absolute alcohol is germicidal; it also blunts sensation.

The needle is introduced gently and passed to the bottom of the follicle or until it meets resistance. The current is turned on until the follicle becomes white, or the bubbles show the position of the hair follicle. The hair is then withdrawn and the needle is returned into the orifice till it meets the papilla. Sufficient current is used to destroy the papilla. By this method the least possible tissue is destroyed. At the end of the sitting the patient should wash the face in hot water and apply a cold cream. During the day an antiseptic evaporating lotion such as aluminium acetate or calamine lotion may be used. Additional internal treatment is given by many dermatologists. As a rule neither redness nor swelling results even after an hour's work although results vary in different patients, and in the same patient at different times. Often slight traces of the work remain for a day or two, but these fade away and the skin is left free from any blemish.

Baum uses a needle rounded on the end and preferably olive-pointed. The needle-holder has in the two jaws rivets with channeled heads which grasp the needle admitting a pivotal movement and allowing a rapid adjustment of the needle to any angle conforming with the axis of the hair shaft. Thus the operator can rest his hand on the patient's face. The hand does not encroach on the field of vision and steadiness, speed, and accuracy are assured. The patient grasps the positive pole. Should there be difficulty in returning the needle to the empty follicle, the patient breaks the connection until the introduction of the needle in order to avoid superficial electrolysis. The current used is from one-third to one milliampere. Although with this current more time is required for the work than with a stronger current, no pain is caused, and better results are secured.

It is important to measure accurately the amperage. The development of bubbles about the needle is not a safe guide.

The LeClanché type of cell (the carbon cylinder, ammonium chloride type) furnishes the smoothest and most satisfactory current. This is bulky, but on the other hand it is both cheap and durable.

In case the skin is irritable to treatment it is better to postpone the sitting. The application of cocaine or the like is to be avoided.

Closely grouped hairs should not all be removed at one time, and the areas treated should be as symmetrically arranged as possible. All reaction from the treatment must be allowed to pass before the remaining hairs are removed.

Within practical limits the smaller the diameter of the needle's shaft, the better will be both technique and results. The minimum current that will destroy the papilla should be used. Even a few returns are preferable to scarring. Baum reports that his patients often fall asleep during a treatment. He has frequently removed from sixty to seventy hairs in an hour. The number of hairs removed at one sitting depends upon the sensitiveness of the individual skin, varying on the average from forty to sixty or seventy.

Scarring and pain depend upon the sensitiveness of the skin and the dexterity of the operator. Pain is often due to too strong a current. The upper lip is the most sensitive part of the face operated on. There seems to be special danger of scarring in the region of the eyebrows, although the result is sometimes satisfactory. There is frequently at the base of the coarse hairs a sort of underbrush of finer filaments. After the coarse hairs are removed these finer hairs become noticeable. They would probably in any case have grown coarse in time. Electrolysis is

generally believed to be suitable for only the coarser hairs. Even at the best it is tedious and expensive.

As the direction of the hair root may be perpendicular or oblique, the operator does not always reach the papilla and such hairs consequently grow out again and require a further operation. This is especially true in regard to the hairs on the chin.

The reliability and skill of the operator are very important factors of successful treatment. "This operation has unfortunately found its way into the hands of the unprincipled and the ignorant, who, in their efforts to extract money from the credulous, have in some of the larger cities brought electrolysis for hypertrichosis into ill repute." The hair is destroyed by the electrolytic action at the negative pole during the passage of the current.

A new growth often occurs in the vicinity of the region of operation. The patient should be impressed with the inherent tendency of a hypertrichotic skin to produce hair. By giving treatment regularly every few months the hair may be kept inconspicuous.

Michel of Saint Louis first devised this treatment in 1875 for the removal of ingrowing eyelashes. Hardaway of the same city later popularized it for the purpose of removing superfluous hair. But as is the case with other methods, the results of electrolysis vary largely with the individual patient and with the skill of the operator. The method is most successful in cases in which a few scattered hairs are present in women of middle age. A good percentage of hair permanently destroyed at one treatment may be placed at about eighty per cent.

Electrolysis requires a delicacy of touch that most men do not possess. One, indeed, must be an artist to use the electric needle effectively. Nevertheless on account of the advantages of this method in comparison with other methods of epilation, electrolysis may well be considered at present as the best treatment for the removal of hypertrichosis.

EMMA E. WALKER.

Hypertrophy.—In its broadest sense hypertrophy is an increase in substance of an organ or tissue, due either to an increase in the number or size of its individual elements, or to a combination of both these changes, without other alterations of structure. An increase in size alone of the individual cells is known as *quantitative* or *true hypertrophy;* increase in the number of cells alone as *numerical hypertrophy* or *hyperplasia.* The gross changes in hypertrophy are: increase of size and weight, in the case of hollow organs a thickening of the walls; increase in consistence; and in the case of muscle a darker color due to an increased formation of muscle pigment. Hollow organs when viewed externally may not give evidences of hypertrophy, since the increase of size may take place at the expense of the cavity, as in the case of concentric hypertrophy of the heart. The weight of an organ is the most reliable standard for the judgment of hypertrophy, but it must be borne in mind that both increase in size and weight of tissues may be due to other pathological conditions than true hypertrophy or hyperplasia. It therefore becomes necessary to make sure than an apparently hypertrophic organ is of normal structure, and this is possible only on microscopical examination.

Microscopically, true hypertrophy is shown by increase in size of the individual cells with increase in size and staining power of their nuclei. Since there are individual differences in the size of cells a standard of comparison can be obtained only by the most exact measurement of the cells of the tissue in question Hypertrophy of the nucleus may exist without enlargement of the cell body. The practical distinction between true hypertrophy and hyperplasia is often difficult; they usually exist together. Numerical atrophy may be combined with true hypertrophy, the cells may be increased in size, while diminished in number; on the other hand hyperplasia is often accompanied by a loss of bulk on the part of the individual elements. Only very rarely do all the cells of a tissue or organ show a uniform hypertrophy; atrophic cells usually exist side by side with those of increased size.

The causes leading to hypertrophy may be either intrinsic or extrinsic. In the former case morbid impulses to growth or multiplication either exist in the germinal cells or arise through germ variation. Such impulses may develop during either intra- or extrauterine life; the hypertrophy may be present at birth or develop in early life without the participation of any extrinsic factor. They may be ascribed to an increased tendency to growth and cell multiplication or to an absence of the normal inhibitory influences, but beyond such theoretical explanation we cannot as yet venture. Intrinsic hypertrophy is usually spoken of as congenital or inherited hypertrophy. The hypertrophies not dependent upon congenital tendencies are usually the result of an increased functional demand, increased nutritional activity, or of a disturbance of the normal equilibrium between growth and decay. Underlying hyperplasias are the factors leading to cell division.

Intrinsic Hypertrophy.—The more common forms of overgrowth due to congenital tendencies are: general and partial giantism, ichthyosis, localized hyperkeratosis, verrucose nevi, elephantiasis, macroglossia, macromeilia, macrocheilia, lipomatosis, hypertrichosis, hyperonychia, onychogryphosis, leontiasis, exostoses, etc. Hypertrophy due to congenital excessive impulses of growth rarely affects the internal organs; but certain hypertrophies of brain, thymus, lymph glands, spleen, etc., are at present explained as being of congenital origin. The early development of the sex-organs (pubertas præcox), and the hypertrophy of the breasts at puberty and during pregnancy are likewise due to congenital tendencies. Hypertrophy of the mammæ in the male (gynecomastia) may be an inherited condition, all of the males in the family line showing this peculiarity. It is impossible to say to what extent the various forms of hypertrophy mentioned above as being of congenital origin are in reality the result of intrinsic forces, since similar proliferations, ichthyosis, elephantiasis, etc., may be caused by external influences. However, in those cases in which the hypertrophic growth is of hereditary nature and appears early without adequate extrinsic cause, the grounds for considering the existence of a congenital predisposition are very good. Even in those cases in which the overgrowth was excited by external injurious influences the existence of a congenital predisposition is not precluded, since we know by experience that such causes give rise to pathological changes of this nature only when there is a special predisposition inherent in the tissues.

Acquired Hypertrophy.—The most common varieties of hypertrophy due to extrinsic influences without the cooperation of congenital predispositions are: hypertrophy due to increased functional activity (overwork), hypertrophy caused by lessened wear, hypertrophy resulting from failure of involution, hypertrophy caused by removal of pressure (hypertrophia ex vacuo), and finally hypertrophy caused by chronic irritation, either chemical, mechanical, or infectious.

Hypertrophy from overwork occurs most frequently in muscles and glands, rarely in other tissues. The physical and chemical changes in the muscle cell or gland cell resulting from increased function in some way stimulate cell growth. Any increase in functional stimuli not too intense is attended by an increase in the substance of the organ. The degree of the hypertrophy depends upon the age of the individual and the general state of the nutrition. Increased work on the part of the heart due to valvular, arterial, pulmonary, or renal conditions causes a more or less

marked hypertrophy of that part of the heart upon which the greater share of the work falls. Such hypertrophy being in compensation for the disturbances of circulation produced by the primary pathological condition is known as *compensatory hypertrophy*. Either side of the heart alone may be affected or the entire organ may become enlarged. Further, hypertrophy of individual muscle bands or layers may occur according to the functional demands of the case. Compensation is more nearly complete in the case of young and well-nourished individuals. Increase in bulk of the voluntary muscles follows increased muscular exercise. The fibers increase both in length and in thickness, and there is most probably an increase also in the number of the fibers. Hypertrophy of individual muscle groups occurs in certain trades or occupations (laborer's hypertrophy). Hypertrophy of the involuntary muscle occurs physiologically in the pregnant uterus, the muscle cells attaining a size of seven to twenty times the normal length and five times the normal breadth. In the case of uterine tumors and hematometra hypertrophy of the uterine wall may also occur but to a less degree. Hypertrophy of the muscular coat of blood-vessels occurs in conditions of increased blood pressure, particularly in the case of the dilatation of vessels in the establishment of a collateral circulation. In the case of enlarged prostate, urethral stricture, calculi, etc., the bladder walls may become greatly thickened; a similar hypertrophy of the muscularis of stomach and intestines may occur above a stricture.

The functional glandular hypertrophies are chiefly *vicarious* or *compensatory*, and occur especially in those glands that have but little capacity for regeneration, but are capable of compensatory hypertrophy. Such compensatory hypertrophy occurs in the liver, kidneys, adrenals, testis, thyroid, mamma, and parathyroid.

Of the glandular organs the kidneys and liver are most capable of undergoing hypertrophy. In increased functional activity of the kidney, as in the case of diabetes and excessive drinkers, both kidneys may become enlarged. Compensatory hypertrophy of one organ may take place after the destruction or removal of the other, so that the remaining kidney may in size and weight equal or exceed that of two normal kidneys. The younger the individual, the more complete the compensation. On microscopical examination the enlargement is found to be due chiefly to a hypertrophy of existing structures; the glomeruli are larger, the tubules dilated, more convoluted and longer, with larger epithelial cells; but in young individuals a hyperplasia of tubules and glomeruli may occur.

Hypertrophy of the liver as a whole is extremely rare. Destruction of a portion of the liver substance is followed by a hypertrophy of the remaining normal liver tissue. The lobules become larger and also increase in number. The liver-rods are broader, more cellular, and the individual cells much larger. New liver-cells are formed from proliferating bile-ducts. In animal experiments it has been shown that complete restoration of as much as half of the organ is possible. In simple or inflammatory atrophies of the liver hypertrophy of single cells is very common.

Destruction of one adrenal may be followed by compensatory hypertrophy of the other. In the case of the salivary glands, mammæ, ovaries, and testicles, compensatory hypertrophy does not take place at all or only to a slight degree, except during the developmental period. Hypertrophy of the mamma has been found in connection with galactorrhea, and in one-sided lactation after loss of one breast.

Removal or destruction of a portion of the thyroid is rarely followed by hypertrophy of the remaining thyroid tissue, but the hypophysis suffers an enlargement which must be regarded as compensatory in nature. The writer has seen in a case of acromegaly an enormous hypertrophy of the parathyroids which might possibly be explained as being of the nature of a compensation for the hypophysis. Between thyroid and hypophysis, and thyroid and thymus there exist close functional relationships, so that disturbance of the function of one organ may cause the other to become hypertrophic (cretinism, myxedema, cachexia strumipriva, exophthalmic goiter). Such vicarious hypertrophy can be explained as the result of the *chemical correlation* of different organs; a disturbance of such correlation may lead to the hypertrophy of an organ of entirely different structure from the one that has lost its function. Hypertrophy of the hypophysis after castration, during pregnancy, and after destruction of the adrenals, thymus, and lymph-node hyperplasia in exophthalmic goiter, thymus hyperplasia after loss of the chromaffinic tissue of the adrenals, enlargement of the thyroid in pregnancy, the development of acromegaly in adenoma of the hypophysis, precocious puberty with disease of the hypophysis, hypertrichosis associated with hermaphrodismus or disease of the adrenals, hypertrophy of adrenals in hermaphrodismus and after castration, general obesity in disease of the hypophysis, functional hypertrophy of mamma in malignant syncytioma of testis, etc., are striking examples of vicarious hypertrophy due to disturbance of chemical correlation (theory of hormone-action).

Agenesia or aplasia of one lung may be compensated by hypertrophy of the normal organ, and a similar compensation may occur in early life in conditions leading to disuse of one lung. In later years, however, the loss of one lung is followed only by an emphysematous distention of the other, which usually leads to atrophy of the alveolar walls and not to hypertrophy. Emphysematous distention of the air spaces with hyperplastic thickening of their walls has been observed in the lungs of athletes, singers, and players of wind instruments.

Compensatory hyperplasia of the different blood-forming organs, spleen, lymph glands, and bone marrow in conditions affecting one or the other is not uncommon. In various forms of anemia, leukemia, etc., where the function of either the spleen or bone marrow is inadequate, the hemolymph glands become enlarged and suffer structural changes by which they come to resemble either splenic tissue or lymphoid marrow.

Compensatory hyperplasia of the fibula has been observed in cases in which through disease the tibia had been rendered useless in the support of the body.

Hypertrophy from lessened wear occurs particularly in the case of the nails and teeth. If the wear of the nails be prevented, or if they are left uncut, they may become very much enlarged. Such conditions are, of course, not true hypertrophies in the narrower sense. Teeth growing irregularly, so that the cutting or grinding surfaces are not brought into apposition develop into the so-called tusks. In animals the claws and beaks of birds, and the teeth of rodents may through disuse form extensive overgrowths.

Removal of pressure as in the case of atrophy of the brain may lead to a thickening of the inner table of the skull. Similarly in other regions of the body removal of the normal pressure is often followed by hyperplasia of the adipose tissue (increase of fatty capsule and pelvic fat in atrophic kidney, infiltration of fat in atrophic pancreas, lymph nodes, heart and voluntary muscles). Such fatty infiltrations are not true hypertrophies but are fatty metaplasias of existing connective tissue as the result of local or general metabolic disturbances.

Failure of the normal involution of the uterus after pregnancy gives rise to an abnormally large uterus during the non-pregnant state. The thymus gland instead of disappearing at the usual period may persist or even show enlargement. Failures of involution, likewise, are not hypertrophies in the narrow sense.

As the result of slight prolonged or frequently repeated mechanical irritation local hyperplasias of tissue may arise (local ichthyosis, callus, corns, etc.); hyperplastic overgrowths are also caused by chemical action hypertrophy of bone caused by phosphorus and arsenic); and finally infective inflammations frequently give rise to overgrowths or new formations of tissue (condyloma, tuberculous and syphilitic processes, actinomycosis, etc.). Chronic inflammations of the skin are often characterized by hyperplasia of fibrous connective tissue resembling elephantiasis; in syphilis extensive overgrowths of bone not infrequently occur. In inflammatory affections of the lung and pleura, as well as in congenital heart lesions, enlargement of the terminal phalanges and articular ends of the long bones may occur (ostéoarthropathic hypertrophiante). The so-called clubbed or drumstick fingers acquire an important diagnostic significance in these conditions. Hyperplasia of the spleen and of the lymphadenoid tissue throughout the body is of not infrequent occurrence. The nature of such overgrowth is as yet obscure, but it is most likely of infectious or toxic origin. In a number of cases the hyperplasia of the lymph glands has been shown to be an atypical tuberculous process, and very recently diphtheroid bacilli are reported as a probable cause of the lymph node hyperplasia of Hodgkin's disease.

The extensive hypertrophy of the bones and internal organs observed in the condition known as acromegaly forms one of the most interesting varieties of the acquired hypertrophies. The nature of this disease is as yet unknown; in the majority of the cases an adenomatous hyperplasia of the hypophysis has been present and this has been regarded as the cause of the disease. Other writers have explained it as due to a congenital predisposition, to disturbances of the pineal body, sexual organs, thymus, or thyroid, or to abnormal nervous influences. Closely related to acromegaly are the conditions of *giantism*, *leontiasis ossea*, and *Paget's disease* (ostitis fibrosa). That disturbances of the hypophysis play an important part in acromegaly and many cases of giantism cannot be doubted; but the relationship is not yet clear. The other forms of osseous hypertrophy still require a satisfactory explanation of their cause and nature.

General Considerations.—Both true hypertrophy and hyperplasia are to be regarded as being of unstable nature, inasmuch as they depend upon the duration of the cause and the increased supply of nutrition. Increase of size demands also increase of space, and in the case of some of the organs and tissues a space limit may be ultimately reached. Hypertrophic tissue requires hypertrophic vessels to furnish the increased amount of blood needed. Changes in the vessels or in the circulation by which the supply of nutrition is diminished lead quickly to atrophy and fatty degeneration of hypertrophic tissue. Similarly diminished functional activity, particularly in the case of the heart and voluntary muscles, is followed by rapid fatty degeneration of the muscle fibers. Further, the inherent vitality of cells, particularly their histogenetic vitality, is limited; tissues which have used up their reserve in compensating for some deficiency are the sooner exhausted. A heart in a state of compensatory hypertrophy may not be able to meet ordinary emergencies which under normal conditions have no effect upon the non-hypertrophied heart; that is, a heart though hypertrophic may be insufficient. Sooner or later, therefore, a failure of compensation must occur, such failure depending upon many factors: inherent cell vitality, conditions of nutrition and removal of waste products, functional activity, etc. In general it may be said that, while fully developed heart and voluntary muscles are desirable, compensatory enlargement due to excessive exercise, increased nervous stimuli, etc., as in the case of the "athletic heart," "smoker's heart," etc., must be regarded as distinctly pathological, inasmuch as such hypertrophy is at the expense of the heart's reserve power.

ALDRED SCOTT WARTHIN.

Hyphomycetes.—Most of the hyphomycetes or mould fungi are not pathogenic and are of interest to us only as organisms which are apt to contaminate our bacteriological media. Some of them, however, are true parasites, among which the best known are the *Achorion schönleinii*, *Trichophyton*, *Oidium albicans*, and *Microsporon furfur*. These can be only briefly touched upon in this article, as they are not bacteria, and yet some reference to them would seem to be called for here.

ACHORION SCHÖNLEINII (*Favus Fungus*).—This fungus, which is the cause of favus in man and animals (horses, cattle, dogs, cats, rabbits, mice), was discovered by Schönlein in 1839. The disease is communicated to man by contact with animals. Want of cleanliness is a contributing factor. The fungus seems to find a more favorable soil for its development on the skin of persons in a debilitated condition, especially from phthisis, than in healthy individuals.

Pathologically the disease represents the reaction of the tissues to the irritation caused by the growth of the fungus, the spores finding their way into the hair follicles, where they develop around the hair seat. The achorion grows in the epidermis, the density of the growth causing pressure on the parts below, thus crushing out the vitality of the hair and giving rise to atrophic scarring. This disease shows a marked preference for the scalp possessing hair but it is also found on skin devoid of hair, and even the mucous membranes or the nails may be attacked. Kaposi describes a case of favus universalis. On the scalp it first appears as a tiny sulphur-yellow disc or *scutum*, depressed in the center like a cup and pierced by a hair. This is the characteristic lesion. The cup shape is attributed by Unna to growth at the sides proceeding more vigorously than at the center.

According to Unna, Quincke, and others there are several varieties of favus fungi, but later investigations would seem to indicate that the achorion Schönleinii is the only species of fungus producing favus.

As seen under the microscope the mycelium consists of branched radiating hyphæ. Some of the hyphæ swell at their free ends, becoming club-shaped, while others give off lateral buds containing Kral's so-called "yellow bodies," which rupture, allowing their contents to escape as free bodies. When this takes place, moss-like offshoots develop in the form of dense, twisted threads. Later, the individual threads break up into cell-like, oval structures.

The favus fungus is readily cultivated at both room and body temperatures on the ordinary nutrient media. The growth develops slowly and shows a preference to grow beneath the surface of the medium. The characteristic form of growth is that of moss-like projections from a central body, the color being at first grayish white and then becoming yellow. To obtain the fungus in pure cultures the "favus crusts" are mixed with sterile silicic acid, reduced in a sterile mortar, and plate cultures on gelatin or agar are made from this mixture. Blood serum is the only medium on which the spores are developed, the most favorable temperature being 30° C. Artificial infection can be produced only with material containing spores.

TRICHOPHYTON (*Ringworm Fungus*).—Ringworm of the body or hairless parts (tinea circinata), and ringworm of the hairy parts (tinea tonsurans and tinea barbæ or sycosis) are due to the fungus trichophyton, discovered by Gruby in the human hair, and between the epidermal cells by Hebra.

According to Sabouraud (whose conclusions are based on an exhaustive series of microscopical examinations of cases of tinea in man and animals, of cultivation of artificial media, and of inoculation experiments), there

are two distinct types of the fungus trichophyton, causing ringworm in man; they are distinguished by the size of their spores—one with small spores 2 to 3μ in diameter, which he calls Trichophyton microsporon, and another with large spores, 7 to 8μ in diameter, which he calls Trichophyton megalosporon. These differ both in their mode of growth on artificial media and in their pathological effects on the human ski and its appendages.

Trichophyton microsporon is the common fungus of tinea tonsurans in children, more particularly the severe affection known as the "Maladie de Gruby," which is rebellious under treatment, and its special seat of growth is the substance of the hair. Trichophyton megalosporon is essentially the fungus of ringworm of the beard and of the smooth parts of the skin in adults.

Under the microscope the single mycelial threads are distinctly separate and from them conidia are given off. The spores of T. microsporon are contained in a mycelium; but this is not visible, the spores appearing irregularly piled up like zoöglea masses; and growing outside, they form a dense sheath around the hair. The spores of T. megalosporon are always contained in distinct mycelium filaments, which may be either resistant when the hair is broken up, or fragile and easily separating into spores.

The trichophyton grows at room temperature, but best at 30° C. on the usual media. It liquefies gelatin, agar, and blood serum. The two types when grown on artificial cultures also show a downy surface and white color; those of T. megalosporon a powdery surface, with arborescent peripheral rays, and often a yellowish color.

Although the morphological appearances, mode of growth and pathological effects of each type of trichop hyton show certain characters in common, yet there are some constant minor differences which point to the fact that there are several varieties or species of fungi included under each type. The species included under T. microsporon are few in number, and with one exception (that which causes the contagious herpes of the horse) almost entirely human. The species of T. megalosporon are numerous, and many animals as well as man are subject to affections caused by the various species.

In contradistinction to other fungi, the cultures of trichophyton retain their vitality for a long time. The disease has been produced artificially in animals by inoculation with material containing spores.

Oïdium Albicans (*Thrush Fungus*).—This fungus, which was discovered by Bery and fully described by Gruby, is the cause of thrush, and occurs in all mucous membranes with squamous epithelium, especially in the mouths of infants, where it is manifested by white points or patches on the inflamed surface. The usual seat of thrush is the buccal membrane of children, but occasionally it occurs in the faucial and esophageal surfaces; rarely in the middle ear, trachea, and subdiaphragmatic portion of the digestive tract.

Under the microscope this parasite is seen to consist of mycelial threads; numerous spherical or ovoid spaces or conidia are also present surrounding the mycelium and covering the epithelial cells.

The oïdium albicans is strongly aërobic, growing on all the usual culture media in the presence of oxygen, best at 37° C. It does not liquefy gelatin, upon this medium forming white colonies. On agar a yellowish-white growth is developed.

It is pathogenic for rabbits when inoculated intravenously, the fungus becoming localized in the internal organs.

Haller considers that this organism is identical with, or very closely allied to, the *oïdium lactis*, which occurs in milk undergoing acid fermentation.

Microsporon Furfur (*Pityriasis Fungus*).—This fungus is the cause of tinea or pityriasis versicolor, and is found in the scales cast off by the skin in this affection. When these scales are treated with a five-per-cent. solution of caustic potash and examined microscopically, short, slightly branched mycelial threads are seen with very large conidia lying together in clusters. The fungus has not been cultivated artificially, but tinea versicolor has been produced by experimental inoculation, both in men and animal.

Arthur R. Guerard.

Hypnotics. These are remedies which aid in the production of sleep. In general they are greatly abused by the laity, and even by the physician. Sleep is as often a function utilized to push out of consciousness the petty pin-pricks of life as it is to overcome the effects of bodily fatigue. Sleep is more utilized to prevent tire than as a function of recovery from fatigue. There is little doubt that most people sleep too much, just as they eat too much, and it is notorious that the ablest productive workers in the community are seldom those who sleep excessively. It is rarely the smoothly working, busy individual who needs hypnotics. When such a one wishes to sleep, he withdraws his attention from the external work, starts a pleasing fantasy which soon passes him into the depths of unconscious fantasy, *i.e.* into his instinctive feeling life of dreams. It is the troubled and worried and distracted person, one who is discontented, or idle, or ill who requires help to shut out the external world which claims attention. Sensory stimuli, either as hallucinated forecasts of the future, as anxiety and desire, as the replacement of one unpleasant image by another, or as the result of actual pain, these constantly pour into the cerebrum and demand attention, and some adequate motor outlet. It is not enough that optic, auditory, temperature, and tactile stimuli be reduced to a minimum. Such patients need either a psychical freeing from their conflicts, or a physico-chemical dulling of the sensory pathways which interferes with the cortical functioning. If they cannot find the adequate answer to their problems they must prevent the brain attempting to offer a solution, by short circuiting it as it were. This is the function of the hypnotic, and because it can so readily rid the individual of his conflicts it is no wonder that hypnotics are greatly abused.

The hypnotics can be grouped generally under three heads: (1) Those containing the alcohol radical in some combination, (2) those containing the bromine ion, and (3) a group not really hypnotic, but really analgesic. The members of this group are capable of alleviating pain, and hence aid sleep by cutting off pain stimuli; they should never be used as hypnotics unless there is pain, and only then when the cause for this pain is definitely perceived by the physician. The presence of psychical pain is no excuse for the use of the members of this group; it is an unconscious subterfuge on the part of the patient to obtain an artificial nirvana at the risk of developing serious consequences as a drug habitué.

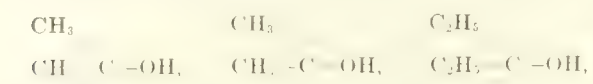
The Alcohol Group.—These are the most widely used and the most valuable. Their pharmacological action is similar, with certain variations due to rate of absorption, elimination, and diffusibility, as well as their specific activity upon the nervous system. This selective action of the hypnotics of what is here called en bloc the alcohol group—containing many substances not distinctly of this chemical character—is due to the affinity of the hypnotic for the lipoid or fatty substances within the protoplasm: The central nervous system is characterized by its high percentage of such fatty substances. Any narcotic (hypnotic) substance depends for its distribution upon its relative solubility in fat and in aqueous media. The solution affinity of the narcotics for lipoids determines the proportions in which they accumulate in different

tissue cells, and the narcotic (hypnotic) action is essentially due to the solution reaction with the nerve tissue lipoids. This solution reaction with the lipoids also diminishes oxidation which in its turn aids in depressing not only the cells of the nervous system but all of the cells of the body.

Hence the hypnotics of this general group act by depriving the protoplasm (lipoid constituents chiefly) of their activity thus interfering with the passage of impulses (blocking). They thus shut out the external world from the psychical mechanisms and permit the patient to pass into the depths of the unconscious. This is sleep in its various grades.

The chief members of this group are alcohol, paraldehyde, chloral hydrate, chloralamid, dormiol, isopral, amylene hydrate, urethane, hedonal, sulphonal, trional, veronal, and proponal. Others appear on the market constantly.

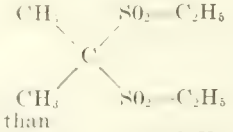
Certain general laws underlie the strength of action of these various hypnotics, and it is upon the basis of their chemical composition that this relationship is established. Thus the primary alcohols are less hypnotic than the secondary, and these less than the tertiary alcohols. Therefore with the substitution of higher radicals the hypnotic power increases; thus in the tertiary alcohols



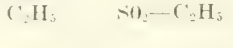
the narcotic power gradually increases with the substituting of ethyl C_2H_5 radicals for the lower CH_3 methyl radicals.

This is also true for certain alcohol radicals introduced into the sulphone series, as sulphonal and trional, for example.

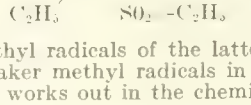
Sulphonal



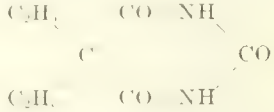
is less active than



trional



by reason of the two ethyl radicals of the latter replacing the relatively weaker methyl radicals in the former. A similar result works out in the chemical composition of veronal:



From the toxicological side it is noted that the tendency is toward a dissociation of function, in which the ancestral pattern of the nervous system is a determining factor. The members of this group dissociate or separate the constituent metameres of the nervous system. The highest functions, that is those latest acquired, are first involved; hence the more intricate psychical processes of intelligent, logical, social value are first affected; the coordination of motor activity between different levels next commences to break down, first in the higher mechanisms, speech, ocular, etc., then those of the midbrain and spinal cord, until finally the medullary centers controlling the oxidation (respiration) of the bodily cells succumbs and death results from respiratory paralysis.

With these general actions are a number of side actions.

Alcohol itself is frequently used as a hypnotic, chiefly as beer, porter, or stout the heavier wines, or whiskey and gin. As continuous hypnotics these are highly disadvantageous, not only inducing alcoholism as such, but because of the general tendency to produce cellular degenerations of the nervous system, of the kidneys, and of the liver. Furthermore, in small doses a slight motor excitement produced may interfere with its hypnotic action, which only larger, hence harmful doses, can overcome.

It is often a tenuous line that separates the need for a hypnotic as an aid to a needed sleep from an unconscious self-indulgence of an alcoholic drink to gain refuge from self, which refuge should be gained in some more healthy manner.

In temporary upsets, the milder alcoholic drinks may be advantageously used, but one should recommend them with great caution.

Paraldehyde (CH_3COH) is a useful hypnotic. It is widely used where it is needed frequently as in allaying mental excitement in a number of psychotic states. Its large dose, ʒi–ii, and its disagreeable taste tend to reduce the habit formation to a minimum, although some acquire the taste for it. It has relatively few harmful side actions and at times may be given up to ʒi (30.0). Much of it is excreted by the lungs, thus giving a peculiar breath persisting for twenty-four to forty-eight hours after its administration.

Chloral hydrate ($CCl_3CH(OH)_2$) which is easily administered by reason of its ready solubility in water, but which has an irritating odor and biting taste, should be well diluted to avoid an irritating effect upon the stomach. It should never be administered hypodermically. It acts as chloral, not being broken up in the body, and is mainly excreted by the urine unchanged, or chiefly as urochloralic acid (reducing copper oxide, hence false sugar reaction).

The dose is from five to fifteen grains, the hypnotic effects are prompt and sleep is usually prolonged. In excited individuals, acute maniacal excitement, from delirium tremens, paresis, manic phase of a manic depressive psychosis, hysterical delirium, exhaustion delirium, doses of gr. xv–xxx (1.0–2.0) may be given but doses over two to three grams may prove very dangerous chiefly by reason of its side action on the heart and blood-vessels. It is to be avoided with fatty, arteriosclerotic, and myocarditic hearts, as sudden death has resulted even in hypnotic doses of gr. xv (1.0).

Continuous usage of chloral is dangerous. It leads to a protein decomposition as in phosphorus poisoning, and causes pronounced parenchymatous degeneration in many important organs. Acute poisoning by chloral as shown by coma, cyanosis with abolition of reflexes (corneal, patellar) and weak heart action, is best treated by washing out of the stomach, artificial respiration, caffeine [coffee by mouth or rectum] camphor and strychnine. The patient should be kept warm. A habit may be formed.

Chloralamid.—($C Cl_3 CH(OH) N (CHO) H$) is a chloral substitute. It is broken down into chloral when taken by mouth. Hence it has the same action. It acts more slowly—one-half to two hours—and is given in larger doses, gr. xxx–xlv (2.0–3.0).

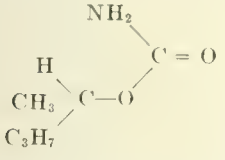
Dormiol and *Isopral* are more recent substitutes neither of which offer any special advantages. The former is a mixture of chloral and amylene hydrate. It is a camphor-like liquid administered in capsules of gr. viiss (0.5) to gr. xx (1.5) and acts in from half an hour to an hour. The latter is a higher alcohol with chlorine, acts rapidly (fifteen minutes to half an hour) and is administered in doses of from gr. viiss–xv (0.5 to 1.0). It has a distinct cardiac depressing activity and should be given with caution.

Amylene Hydrate CH_3 CH_3 COH is a tertiary alcohol of this group. It is a thickish oily liquid somewhat

resembling paraldehyde and is slightly more toxic. It has a depressing cardiac action similar to but less than chloral and is given in doses of from gr. xv–xxx (1.0–2.0), causing sleep in from a half to three-quarters of an hour. At times it increases rather than decreases motor restlessness. It is given by mouth, in capsules, or by enema.

Urethane NH_2 C_2H_5O >C = O is of clear crystalline appearance, soluble in water, with a salty taste. It is an uncertain hypnotic in doses of gr. xxx (2.0), although apparently free from deleterious side effects.

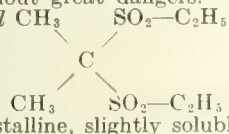
Hedonal is related chemically to urethane. The ethyl radical in urethane is replaced by hydrogen. It is also crystalline,



soluble in water with a peppermint-like odor and is given in doses of from fifteen to thirty grains. Like urethane, it is inconstant in its activities. It is apt to cause polyuria.

Sulphonal, trional, and veronal are later devised hypnotics of great value though their unrestricted use is not without great dangers.

Sulphonal CH_3 $SO_2—C_2H_5$ was first introduced.

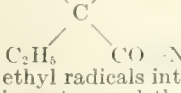


It is a crystalline, slightly soluble in water, bitter in hot liquids, and causes sleep in from one to two hours in doses of gr. xv–xxx (1.0–2.0). Its relatively slow absorption and decomposition give it a relatively longer action, hence it useful in combination in smaller doses with a more rapidly acting hypnotic.

From large doses, or continued smaller doses, undesirable toxic effect may result. These vary from dizziness to confusion, incoordination to ataxia and impaired renal efficiency. The hemoglobin of the blood is also effected. Faulty oxidation or other unknown chemical changes cause the appearance of hematoporphyrin in the urine. This gives the urine a reddish discoloration and is one of the signs to be on guard for in the use of sulphonal or trional. The continuous use of sulphonal or trional is highly disadvantageous and frequently leads to disaster.

Trional and *tetronal* are closely related to sulphonal. Here the methyl group is replaced by ethyl radicals. Trional acts more rapidly than sulphonal. While tetronal is the more forceful, it is to be rejected because of its toxic qualities. Trional is useful, if not used too often, in doses of from fifteen to twenty grains (1.0–1.3). Both trional and sulphonal show hang-over effects.

Veronal C_2H_5 $CO—NH$ is a urea



compound with ethyl radicals introduced. It is only slightly soluble in water, and the average dose is gr. viiss (0.5). An initial dose should not exceed gr. v (0.3) in an unknown woman patient. It causes sleep in from a half hour to an hour. Larger doses cause severe coma, the kidneys become irritated and death may result. The indiscriminate use of veronal by the laity is highly dangerous. Carefully given it is a valuable hypnotic.

Proponal, *Neuronal*, *Bromural*, and *Adalin* are related compounds, the latter with bromine added. They have no particular advantages over veronal but may be used as alternatives or adjuvants.

With reference to this entire group of hypnotics, those containing halogen groups (particularly Cl) have a more deleterious effect upon the heart and blood vessels than those free from such combinations. Habits may be formed by any one of the group and those more in vogue, such as veronal, sulphonal, etc., are not free from danger from the standpoint of habit formation.

The Bromide Group.—A second group of sleep-producing drugs is the bromide group. They contain the bromine ion. They are strictly speaking more sedative than hypnotic. They diminish central reflex excitability. They apparently are able to block out certain reflex pathways, often motor, causing relief from discomfort and hence often stimulate mental activity. The bromides are therefore valuable not so much as producing sleep *per se* as they are in acting as agents capable of blocking off motor excitement; hence they are particularly valuable in combination with certain hypnotics if restlessness is a marked feature combined with sleeplessness.

Single doses are not very effectual, for the bromides act more particularly after a certain saturation has been reached. This is apt to take place because of the slow elimination of the bromide. Although elimination begins shortly after ingestion, less than a fourth of the dose taken is as a rule eliminated within twenty-four hours, and complete elimination takes place only after from ten to twenty days. Hence one must be on one's guard, in giving bromides, to avoid oversaturation and poisoning. Bromide poisoning is extremely common and frequently overlooked. With the continued use of bromides, saturation takes place with a more or less stable equilibrium of income and outgo, but if the amount taken goes up, or some reasons develop limiting the outgo, poisoning takes place. (See Casamajor on Drug Addictions, Vol. II, White and Jelliffe, Modern Treatment of Nervous and Mental Disease.) The bromides replace twenty-five to thirty per cent. of the chlorides in the blood and plasma, and those organs with rich chlorine content. The gastric juice may be taken as an index for bromine saturation. There is thus a relationship between the chlorine and bromine in the bodily fluids under bromide therapy, and more rapid saturation can take place if a salt-free diet is used. This fact lies at the basis of the Toulouse-Richet salt-free diet therapy for epileptics. The injudicious use of bromides results in bromism.

The chief bromides used are those of sodium, potassium, and ammonium. They are all soluble in water and are given in doses of gr. x–lx (0.6–4.0). They should be administered well diluted. Organic bromine preparations are numerous. They all depend for their action on the bromine ion in the alkaline bromide preparations. Some of these are *bromopin*, ʒi ʒii; *brominized sesame oil*, ʒi–ʒii; *bromocol*, ʒi–ʒii; *bromigone*, ʒii.

The general indications for the use of the bromide preparations have been outlined. They are valuable chiefly to quiet states of motor excitement. They are not sleep producing drugs in the narrow sense of the word. They are valuable in cases of restlessness, particularly of emotional origin, and in forms of poisoning—particularly alcoholic or from other drug abuse. They are comparatively safe if kept within legitimate needs, but are to be discontinued when signs of bromism appear.

Analgesic Group.—The members of the third group are very various. Chief among them are the *opium* and *atropine* groups, particularly hyoscyamus. Digitalis may be a hypnotic if sleeplessness is due to cardiac disease. The use of opium as a hypnotic is to be deprecated. Only in extreme cases of pain, in old age or in incurable disease is one justified in using

opium salts for producing sleep. Hence they are mentioned here only to be condemned.

Hyoscine is frequently employed to quiet states of maniacal excitement. It is rarely called for as a hypnotic. SMITH ELY JELLIFFE.

Hypnotism.—*Definition.*—Hypnotism (from ὕπνος, sleep) has to do with the study and practical application of hypnosis. Hypnosis is a peculiar mental condition more or less closely resembling sleep, in which the patient is susceptible to suggestion to a greatly increased degree. The use of various expedients to increase suggestibility dates back to the earliest periods of culture. As long as the idea prevailed that disease was due to the entrance into the body of an evil spirit—and it is not absolutely given up even at the present day—in all methods of cure there was naturally a religious element and procedures having as their object the exorcism of the evil one predominated. As many functional diseases seem to depend upon the obsession of the patient by some dominant idea, which may well carry out the rôle of the actual demon, it is not strange that procedure tending most forcibly to convey the suggestion of recovery have in all ages achieved striking cures. Since suggestion usually works most strongly in conditions in which the bodily functions being as far as possible in abeyance, the attention is concentrated upon the words or actions of the operator or upon a fixed idea, and a certain relaxation and feeling of fatigue are encouraged, it is natural that procedures having as their result this condition of partial mental dissociation which we know to-day as hypnosis (or the hypnotic state) were early discovered and practised.

Hypnosis may be produced through the influence and manipulation of another or by the individual's own concentration and abstraction (autohypnosis).

THEORIES WITH REGARD TO HYPNOSIS.—It is a fact that in hypnosis there is an altered mental condition, but as to the nature of this there is still discussion. That it in many ways resembles normal sleep is true, but between the two conditions there are also points of difference. The idea that it depends upon the entrance into the body of some mysterious fluid, or upon animal magnetism, developed by Mesmer, is practically given up to-day; at least by all those of any authority, while the view that it is due purely to suggestion, originally formulated by Braid and worked out by Liébeault and his successor, Bernheim, is quite generally accepted. There has been, however, a wide difference in the conceptions as to its nature, on the one hand of Bernheim and the Nancy school, and on the other of Charcot and his followers; the former insisting that it is a natural phenomenon which has nothing to do with hysteria while the latter holds that the hypnotic state is a condition of induced hysteria and nothing more.

As to the intimate nature of the phenomena, however, no one has been able to inform us: it is not confined to human beings but is equally inducible in the lower animals.

METHODS OF PRODUCTION.—The methods of producing hypnosis have varied considerably, depending upon the views as to its nature which have prevailed, but they all depend actually, upon putting the subject into a state of lowered resistance to suggestion by encouraging mental concentration upon the matter in hand to the exclusion of everything else and upon setting up a certain feeling of calm and slight fatigue through the monotonous stimulation of one or more senses. They all make use, either singly or in combination, of sensory impressions, continued and monotonous (although occasionally sudden and violent); of the production of a certain degree of fatigue, and of hallucinations or conceptions of sleep aroused by suggestion.

Gazing steadily at some object, bright or dull, the ticking of a watch, the buzzing of the faradic battery, a monotonous strain of music, the rushing of water, or the roar of a train, all have a soporific effect, as has also gentle stroking, always in one direction, of the surface of the body. These impressions being uniform and monotonous, produce a sense of fatigue; the attention is arrested and the suggestion of sleep is favored. The sudden flare of a light or a loud noise may also cause the desired effect, which when so produced has been called "fright hypnosis."

Indian fakirs have for thousands of years hypnotized themselves by gazing fixedly at the tips of their noses, while the monks of Mount Athos get the same effect by prolonged contemplation of the navel. Magic mirrors, or crystal globes and so forth, have also been used with effect. Mesmer in violet garments passed around among his expectant patients to the rhythm of solemn music, touching them with a "magic wand" of iron, or made passes with his hands before their eyes. Various bright objects as small mirrors, metallic balls, or the flame of a candle held near the eyes and somewhat above the field of vision, as well as small magnets, have been used. Again the eyes are closed, and the face or forehead stroked or, the arms being raised, the stroking is carried from the hands down the arm and along the trunk, all these with the verbal suggestion that the subject is sleepy and cannot keep awake. The monotonous auditory stimulus of these constantly repeated verbal suggestions, introduced by Liébeault, is to-day the favorite method of producing hypnosis.

The patient is placed in a quiet room, seated in an armchair or reclining upon a couch or bed, the operator standing before him should in a steady, low and monotonous voice, continue to repeat "You are sleepy," "Your eyes are closing," You are going to sleep," etc. In more refractory subjects the fixation of the eyes upon one of the small objects already indicated may be added, while the verbal suggestion of sleep is kept up.

The sequence of events is as follows: The verbal suggestion of sleep together with stroking, passes before the eyes, or their fixation upon some bright object, being used, the eyelids of the subject begin to droop, where the eyes have been fixed, they cease to converge and the pupils dilate, the body relaxes and the patient presents the appearance of sleep.

Success depends very largely upon the degree of confidence in himself which the operator has, and upon the extent to which the patient surrenders himself to the suggestive influences. A number of attempts may have to be made before a result is obtained; it has been said, indeed, that no one can be hypnotized against his will, but Bernheim asserts that from 80 to 100 per cent. of people are hypnotizable. Probably nationality plays a considerable part.

ONSET OF HYPNOSIS.—The test of success is the presence of suggestibility; the patient appearing to sleep, for example, the arm may be raised, and while gently stroking it, the statement is made that it is stiff and cannot be moved. If it remains fixed against the action of gravity—or cataleptoid—the patient is hypnotized; or he may be awakened, asked if he has been sleeping, and the suggestion repeated. The latter procedure is known as the fractional method. Hypnotization is usually easier after it has been once accomplished; a patient who has been often hypnotized, in fact, becomes liable to fall into hypnosis upon the slightest suggestion or even upon fixing his eyes upon a bright object.

After the desired suggestion has been conveyed, the patient if let alone will probably awaken spontaneously after a time, longer or shorter, depending upon how profound the hypnosis has been; or he may be roused by calling to him, by shaking him, and so forth. He is apt, however, to be confused and dazed

and to complain of headache, a sense of fatigue and oppression for some time, hence it is recommended to proceed as follows: After suggesting that he can be hypnotized by no one else but the operator, he is told that he will presently awaken and will experience no unpleasant sensations, but will feel comfortable and well, that his eyes are opening, that he is awake, perhaps accompanying this last statement by raising the eyelids; or it may be suggested that the patient will awaken at a certain time or upon a given signal, as a knock at the door. Again, stroking in a reverse direction is sometimes used.

Phenomena of the Hypnotic State.—Hypnosis has been divided by different authors into a number of different stages but the division proposed by Forel into (1) somnolence, (2) light sleep, and (3) somnambulism, meets all requirements. In (1) the subject, while his consciousness is impaired, can still resist the suggestions offered, can open his eys, and can perform other acts; in (2) he can no longer open his eyes and is ready to accept suggestions, but later remembers what has occurred during the hypnosis; in (3) there is deep sleep or somnambulism, the subject is readily suggestible, later has loss of memory for events during this period, and may manifest post-hypnotic phenomena, particularly those of cataleptoid character.

Catalepsy is an important symptom in deep hypnosis, both in man and in animals; Charcot was accustomed to induce it by asking the subject to gaze intently upon a bright object held some centimeters before his eyes and then, after a few moments, suddenly withdrawing it. In a successful experiment the patient becomes immobile, his eyes are fixed and staring, the pupils dilated, and there is muscular rigidity of the waxy sort with anesthesia more or less extensive. This condition, if long continued, sometimes passes over into an attack of major hysteria. Suggestibility is great, and after the attack there is complete amnesia for events during the hypnotization and also a sense of fatigue. If the bright object is not withdrawn, but is held continuously before the eyes, the patient falls asleep but his muscles are relaxed, not rigid, while mental clouding is profound. Charcot gave to this condition the name of lethargy. Cataleptoid phenomena are common in animals, as witness the inability to move of a bird "charmed" by a snake, the lethargy of the opossum, etc. Catalepsy may be induced in a rabbit by holding him firmly, his nose to the table, then drawing a piece of chalk gently over his head and nose and on to the table, when the animal suddenly sprawls with head and limbs rigidly extended.

Posthypnotic Suggestion.—Since suggestions which exert their effect only during the hypnotic state can be but of limited value therapeutically, to get a useful result, it is necessary either that their acceptance is continuous after the patient comes out of the hypnosis, or that their action is to become manifest only at some future time, posthypnotic suggestion (*suggestion à échéance*). This persistence as a rule does not occur naturally, but in order to secure it, it is necessary for the operator to insist at the time of conveying the suggestion either that its action will be continuous or that it will not be evident until later. The commonest instance is, that at a given hour the patient will perform some definite act, perhaps foreign to his usual habits. This act may be a very complicated one and may be accompanied by hallucinations more or less vivid, or, on the contrary, the subject while carrying out the act may himself be surprised and embarrassed and unable to explain why he does so.

Forel narrates a number of remarkable instances illustrating the effect of posthypnotic suggestion, among which, one of the most curious is the following:

Under hypnosis it was suggested to a nurse who slept near the room of a very disturbed insane patient whose accouchement was expected, but the exact time was not accurately known, that she would sleep soundly every night until the event was at hand, when she was to awaken and at once summon the doctor. These instructions she carried out to the letter and it is declared that she had no warning from the patient, who was this night continuously noisy as usual, and gave no sign of going into labor. The doctor hastily answering the call, found the child just about to be born.

While these phenomena are curious, they are hardly more remarkable than some things which occur spontaneously and are undoubtedly explainable by natural laws.

The Nature of Hypnosis.—Of the various theories as to the cause and nature of hypnosis, none are satisfying. The question as to whether the hypnotic state is or is not pathological and really a manifestation of hysteria has been vehemently disputed between the Paris and Nancy schools and their respective adherents, without either side having succeeded in convincing the other. Both conditions present in common increased suggestibility, and under the influence of suggestion under hypnosis, it is claimed not only that the subject may be made to carry out a number of queer and contradictory acts after he comes out of it, but that various objective symptoms are also to be produced. Forel expresses himself with regard to this as follows: "One can say that one can produce, influence, and prevent (inhibit, modify, paralyze, or stimulate) all the subjective phenomena of the human mind by means of suggestion and hypnosis, and a large proportion of the known objective functions of the nervous system."

He goes on to describe how suggestion can control menstruation, pollutions, sweat secretion, digestion, the formation of vesicles on the skin, and can call forth both positive and negative hallucinations of the various senses. One cannot but be impressed by the extraordinary similarity of the phenomena described to those known to occur in hysteria. Dercum has expressed his opinion that "To induce hypnosis in a patient is to induce hysteria." Sidis has recently described a condition short of sleep, in which there is increased suggestibility, under the name of the hypnoid state. This, he asserts, is different from light hypnosis, but the distinction is not clear.

Therapeutic Uses.—Of the therapeutic utility of suggestion there can be no question, but as to how it is best to be conveyed, there are great differences of opinion varying from such views as those embodied in the statement of Dercum quoted above, to those of the extreme advocates of hypnotism, who profess ability by its use to cure organic diseases of the nervous system, as hemiplegia and myelitis. As in all such cases the truth probably lies between the two extremes. That a large number of psychoneurotic manifestations may be removed under suggestion is true, but much of this can be affected by suggestion in the waking state apart from hypnosis, which, however, may be justifiable in those who cannot be influenced while awake.

Suggestion under hypnosis has been asserted to cure headaches and other pains, menstrual irregularities, disturbances of digestion, constipation and diarrhea, psychic impotence, masturbation, sexual perversions, and a host of other disorders, both functional and organic, too numerous to mention. Strange to say, many even of its most ardent advocates are cautious in their claims as to its value in hysteria and prefer suggestion in the waking state in this disease. It is certainly of no use in epilepsy, the insane as a rule cannot be hypnotized, and even in the obsessions of the psychoneurotic its influence is doubtful. As to the extravagant claims of cures in organic diseases, we may well be skeptical, though it is to be remembered, that along with organic disease

there are frequently functional neurotic symptoms alleviable by suggestion. Hypnosis to produce analgesia during surgical operations has proved to have but limited application, though suitable suggestions conveyed before anesthetization by ether or chloroform may well aid in the production of loss of consciousness and keep down the quantity of the drug needed, as well as in promoting recovery.

The tendency of recent years has been to use hypnosis rather as an aid to diagnosis in the newer pschoanalysis than as a therapeutic measure, for which last purpose the methods of explanation, persuasion, and re-education, are in most cases found preferable. The lighter forms of hypnosis are still regarded with some favor, however, while the deeper are for the most part avoided. That these last have real disadvantages and dangers even is undoubted. If one holds the opinion of the Paris school and expressed by Dercum, he cannot but doubt the advisability of risking the exchange of what is perhaps a trivial symptom for major hysteria. In such complaints, however, as sexual perversions, alcoholic and drug addictions, the end may justify the means. The chief objections urged against hypnosis are, on the one hand, the weakening of the will and subserviency to the hypnotist which repeated hypnotization produces, and on the other, the danger that it may be improperly used as a means of procuring the commission of crimes or in the case of women, in breaking down their natural resistance to illegimate sexual relations. That the first of these is real is undoubted. Persons frequently hypnotized may become so susceptible that they succumb to even fortuitious influences, are hypnotized by sudden sounds or bright lights, a chance look, or they even yield to autosuggestions and become wretched, helpless creatures. In the case of hysterics, while one symptom may be relieved under suggestion it is usually succeeded by some other, and these patients, frequently hypnotized, are apt to acquire the "hypnotic habit." In fact, it is recommended by the best hypnotists that if the desired effect is not obtained after a reasonable number of hypnotic seances, to give up the practice and to remove the liability of posthypnotic phenomena by a counter-suggestion. The amateur hypnotist constitutes a real danger, and hypnotic exhibitions (though most of them are frauds) should be suppressed. As to the likelihood of criminal acts suggested under hypnosis being carried out, while the possibility cannot be denied, most authorities hold that unless the subject has an element of criminality in his make-up, he will be inhibited by contraconceptions from carrying out criminal acts suggested, and that women will always balk at things offending their innate modesty. The cases supposed to illustrate the opposite view are not entirely convincing. On the other hand, the operator cannot be too careful, since the making of false accusations of assault by women and girls who have been hypnotized is common enough. He should always protect himself by the presence of a third person, preferably a relative of the subject. The dangers of the hypnotizer becoming abnormally amenable to suggestion have been pointed out, for hypnosis, like hysteria, is apt to be contagious. Forel in his book has narrated some peculiar instances of how he himself has been affected.

For the average physician, unless he has acquired the necessary experience and feels confidence in himself, the methods of persuasion and re-education with suggestion in the waking state are open to fewest objections, and in the long run will probably achieve the most solid results. CHARLES LEWIS ALLEN.

Hypochondriasis.—A psychosis characterized by concentration of the mind upon the internal organs. The name is derived from the frequency with which the liver (lying in the right hypochondriac region) is the imaginary seat of disease in these cases.

Hypochondriasis shows a marked preference for males before middle life, but there are hypochondriac females as well as hysterical males. Hysteria is largely a loss of control of the will, whereas the hypochondriac may be a person of strong will. Hypochondriasis develops usually upon a neuropathic basis, so that hysteria and hypochondriasis may be associated.

The psychosis usually rests upon some slight disturbance in the sensory sphere, a hyperesthesia or paresthesia that would be unnoticed in health, but here forms the basis of an imaginary serious malady. As the name implies, the affection is usually located under the cartilages of the ribs, in the liver or some other abdominal organ, and is founded upon the exaggeration of sensations caused by dyspepsia, flatulence, hemorrhoids, etc. But any organ in the body may be the imaginary seat of the disease of which the hypochondriac complains. A slight lesion of the mucous membrane may lead to syphilophobia that may endure a life time. Impotence, that may be induced by the fear of it, may be interpreted as a sign of organic disease of the spinal cord, locomotor ataxia, etc. Palpitation of the heart, so common in gastric catarrh, may lead to the autodiagnosis of heart disease, the patient living in the constant fear of sudden death. Flatulence may induce the fear of a tapeworm that is believed to be consuming the vitality of the body. Lumbago or any alteration in the quantity or color of the urine may form the basis for believing the kidneys are seriously diseased. The fear of cholera during an epidemic may cause the patient to sweat with anxiety and may actually excite a diarrhea.

The mental suffering of the hypochondriac is apparently very real, being equaled possibly only by the acute delight he seems to find in gloating over the details of the symptomatology of his imaginary illness. He will tell his troubles to all who will listen, till he comes to be shunned like a plague. And at all times he shows a keen interest in, and is made delightfully worse, by the exaggerated and erroneous descriptions to be found in the so-called popular literature of the medical fakirs. It is the disease par excellence of the phobias. The fear of tuberculosis is a common form, leading to all sorts of precautions against cold, and sometimes initiating ridiculously idiotic and cruel legislation.

DIAGNOSIS.—This is usually easy. Neurasthenia shows the chronic fatigue upon slight physical or mental exercise, and irritability upon slight provocation. In neurasthenia, the description as to the location and severity of the pain or discomfort will vary from time to time, whereas in hypochondriasis it is more constant as to both severity and location. The depression is usually greater in hypochondriasis, the patient tending to brood over his troubles.

Hypochondriacal delusions are frequently present in melancholia. But the hypochondriac is free from actual delusions and may be quite successful in business and free from domestic difficulties so common in melancholia.

Hypochondriasis shows the characteristic tendency to exaggerate trivial lesions or alterations of function to the dignity of serious organic disease, and to dwell upon the symptoms of these imaginary diseases of organs that are practically normal both in structure and function.

PROGNOSIS.—The prognosis as to life is usually good. The confirmed hypochondriac, with his constant fear of death and extraordinary care of himself at the expense of everyone else, will wear out and survive every member of his family.

TREATMENT.—This is largely a matter of tact. The physician should neither emphasize nor belittle the complaints of the patient. Trivial abnormalities that may serve as the basis for the development of

the psychosis should be corrected so far as practicable. On the other hand, they should not receive undue attention, which serves to increase the patient's introspection. Constipation is usually present and requires attention. As a rule the bitter are better than the saline laxatives. As suggestions we may mention the aromatic tincture of rhubarb, a teaspoonful three times a day; the compound pill of rhubarb, one or two after meals; podophyllin, one-half to one-fourth grain at bedtime; the pill of aloes, belladonna, and strychnine, with or without cascara; the compound licorice powder, one or two teaspoonfuls once or twice a day, or the bitter fluid extract of cascara, one-half to two teaspoonfuls at bedtime.

Sedatives and hypnotics should be avoided.

Dilute hydrochloric acid and the bitter tonics are often useful, since these cases usually show gastric catarrh. Alcoholics, including the alcoholic tonics, are absolutely contraindicated.

The mental and psychic treatment should not be neglected. A strenuous life will leave less time for brooding. Sometimes the intervention of great physical suffering or mental anguish will result in a cure of hypochondriasis. The writer has known such a case now for a number of years, in which the cure seems permanent following business reverses that changed an indolent, purposeless life into one of acute activity. Usually the neurotic basis of hypochondriasis is such that relapses are the rule and permanent cure is difficult. A reasonable amount of worry is good for these patients, in so far as it restrains them from worrying about themselves.

The life of the hypochondriac must be regulated with due reference to the character of the psychoneurosis, and the fact that these cases have a neuropathic basis. The mind and body should be kept busy but they should not be overtaxed. All excesses should be avoided. The hypochondriac must not be too devoted a worshiper at the shrine of Bacchus or of Venus.

Much may be accomplished by regulation of the life and habits of the patient, observance of the rules of hygiene, the use of hydrotherapy and moderate exercise. But every case demands individual study to secure the best results.

Psychotherapy must be applied to the individual. The patient must be made to realize that his case is curable, and he must have full confidence in the ability of his physician. The proper use of suggestion does not require resort to fakery. The patient must be convinced that he will eventually recover. The belief that he will recover may be either a blind faith or the result of reasoning. The latter, the result of persuasion, is rational and scientific and much to be preferred when practicable.

Should persuasion and suggestion prove insufficient, success may follow the intelligent application of psychanalysis. This method of treatment consumes considerable time, but should not be neglected in cases that prove refractory to other treatment. Frequently the psychic cause will be found in the sexual realm, in a conflict between libido and sexual repression.

Freud believes that a sexual factor is paramount in the causation of the psychoneuroses, including hypochondriasis. But this opinion is not accepted by all.

GEORGE E. MALSBARY.

Hypoderma.—A genus of flies, *Oestridæ*. The larvæ of *H. bovis* and *H. diana* have occurred in man, where they cause a migrating inflammation of the skin. See *Insects, parasitic.*

A. S. P.

Hypodermic Medication.—The hypodermic method of administering drugs, now so commonly employed, was first introduced by Dr. Alexander Wood, of Edinburgh, in 1834. It was gradually evolved from the endermic mode of using certain soluble remedies formerly much in vogue, and, as the term clearly indicates, consists in the injection of solutions of suitable medicaments under the skin by means of a small syringe specially adapted to this purpose.

To insure success, care should be taken in the choice of the syringe. The essential qualities are uniformity of caliber of the barrel, a properly fitting piston and a sharp needle attached to the nozzle by means of a water-tight joint. These syringes are now made of glass and of metal, and within late years important improvements have been wrought in their construction, so that excellent instruments may now be obtained in great variety and at very moderate cost.

The original syringes and those of inferior quality still made, consist of a glass barrel with a metal or

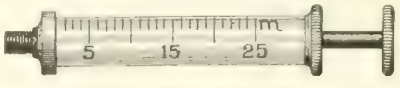


FIG. 3354.

hard-rubber cap at each end, Fig. 3354. This kind of instrument is not to be recommended. It is frail; the mountings, of metal or hard rubber, are liable to be separated from the barrel by very slight force; it is apt to become leaky, and the diameter of the glass tubing is rarely uniform throughout its length. But even in this class of instruments, some superior workmanship is now shown in the best specimens offered by dealers and the former defects, by the employment of skillful devices, have been, in some measure, eliminated.

A decided improvement upon this make is illustrated by Fig. 3355. The glass barrel is inclosed in a fenestrated, sometimes a double fenestrated, metal sheath, which reveals the contents of the syringe when charged, and renders an otherwise weak instrument

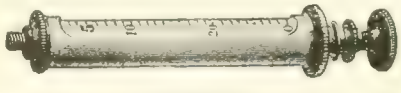


FIG. 3355.

sufficiently strong for ordinary use. It is easily taken apart for cleaning, and to those who prefer the glass barrel it is recommended. Nevertheless, it is open to other objections urged against glass syringes. Unequal diameter of the cylinder and likelihood of leakage are the principal defects.

An all-glass syringe of very fine quality, Fig. 3356 is now made. The barrel is ground with uniform bore and the glass piston is so accurately fitted that no packing is necessary. This instrument is finished with a slide joint, but through the medium of a minute bushing with a screw thread on the outer end, any kind of needle may be attached.

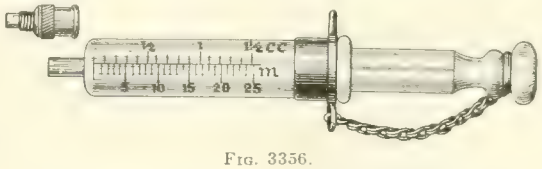


FIG. 3356.

The metal syringes are to be preferred on account of their superior strength and durability, the even diameter of the bored cylinders, freedom from leaks and compactness of construction. The metals used in their manufacture are German silver or brass—plated inside and outside with nickel—pure silver and gold.

Fig. 3357 illustrates an instrument which meets fully the demands for a first-rate hypodermic sy-

ringe. It has a nickel-plated German silver barrel, which is not corroded or injuriously affected by any solution which it is proper to inject into the tissues. The minim scale, in this instrument, is placed upon the semi-cylindrical piston rod, which is made hollow to receive the needle, and is provided with a screw-thread and traverse nut designed to regulate, when set the extent of downward movement of the piston. A cap should be screwed upon the nozzle when the needle is removed. If desired, a drop or two of water

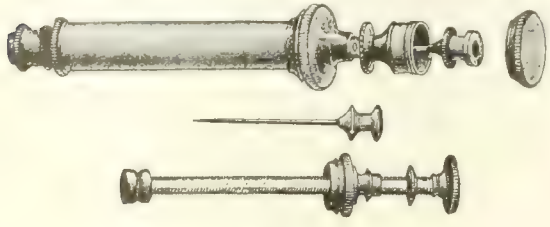


Fig. 3357

may be put in the cap to prevent inconvenient drying of the packing.

More recently, the leather-packed piston has been superseded by a solid metal plunger, which is fitted to the barrel with such precision that the packing is not required, Fig. 3358. Thus the annoyance of a dry and consequently an inefficient packing is obviated, and a thoroughly aseptic instrument may be insured. The hollow piston will receive one or two small needles held in place by the cap screwed upon the end of the rod.

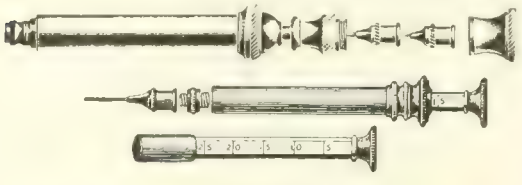


Fig. 3358.

A modification of this excellent instrument is shown in Fig. 3359. This is a metal syringe throughout. The plunger is metal and no packing is used. One needle is encased within the hollow rod and another, affixed for use in the usual manner, is protected by a metal sheath screwed to the barrel.

The metal syringes require no case for their protection. They may be slipped into a chamois-skin or an ordinary pocket knife pouch and carried, without injury, in the vest pocket.

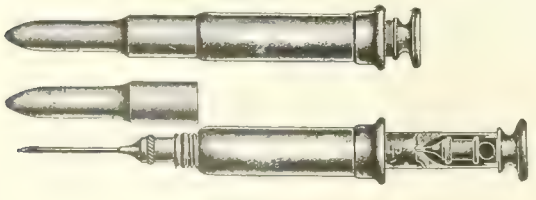


Fig. 3359.

The syringes provided for antitoxins, serums, and bacterins are similar in construction to the ordinary instrument, but are, for the most part, considerably larger. They are made in different sizes, however, to meet varying demands, and range in capacity from 1 to 20 c.c. or more.

Many products of the laboratory, now extensively employed, are supplied by the manufacturer in aseptic glass syringes, fully equipped and ready for use, constituting a most convenient and satisfactory mode of handling and of administering these preparations.

It is prudent to be provided always with an extra needle, which may be enclosed and held by a screw-thread, in a small metal-sheath, furnished by instrument-makers for this purpose.

The gold and silver syringes are not superior in practical utility to other metal syringes and are unnecessarily expensive.

The needles for hypodermic syringes are usually made of steel, plated with gold or nickel. Some advantages are claimed for gold or platinum needles. The needles are attached to the nozzle of the syringe by a screw or a slide joint. The former is the more convenient style. A fine wire should be passed through the needle when it is not in use, to prevent occlusion of the caliber, either by the deposit of crystals from any solution that may have been employed, or by the accumulation of rust. The needles ought to be of small size, with large relative caliber, and it is desirable to have the tips reinforced at the junction with the hubs. The points should be lancet-shaped and free from any groove, depression, or shoulder-like projection.

The use of these instruments requires no special skill, though the dexterous performance of the little operation materially diminishes the discomfort of the procedure to the patient. The skin may be pinched up between the thumb and forefinger of the left hand, while the needle, held perpendicularly to the surface of the pinched-up fold, Fig. 3360, is thrust quickly through it. After penetration, the point of the needle

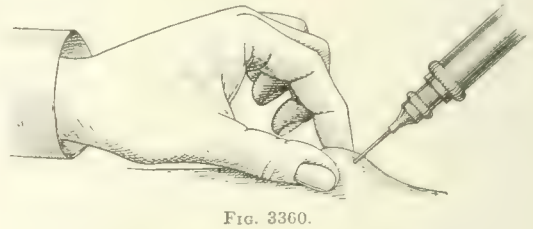


Fig. 3360.

should be passed obliquely to the desired depth into the areolar tissue, and the contents of the syringe slowly discharged. The operator, before making the puncture, should be careful to expel all air from the syringe by inverting the instrument, and at the same time depressing the piston sufficiently to cause a drop of the contained solution to appear at the point of the needle. It is scarcely necessary to urge the importance of rinsing out the barrel and of thoroughly cleaning the needle, immediately after using the instrument.

The injection may be made under the skin in almost any portion of the body; but the vicinity of large vessels and nerves, bony prominences, and specially sensitive or inflamed regions should be avoided. The places ordinarily selected are the arm, near the insertion of the deltoid muscle, and the outer surface of the thigh. The rapidity with which absorption takes place is regulated somewhat by the vascularity of the part into which the injection is made. It is stated by some writers that a prompter effect may be expected from injections into the inner aspect of the limbs, or into the pectoral region, than from similar injections into the outside of the limbs or into the back. If this difference really exists, it must be so slight that it is scarcely worthy of serious consideration, and it would be more than offset by the pain of the puncture, due to the superior sensitiveness of the inner and anterior as compared with the outer and posterior surfaces.

The injections may be superficial, into the subcutaneous areolar tissue merely, or they may be deep, into the body of a muscle, or, as has been recommended in some cases of obstinate sciatic neuralgia, a concentrated solution of morphine may be forced into the very sub-

stance of the nerve itself. Injections are sometimes made into diseased tissues and into abnormal growths. Intravenous and intraspinous or subarachnoid injections are also practised, but a consideration of these procedures, and of hypodermic alimentation, is incompatible with the scope of this article.

The remedies most commonly used hypodermically are morphine, codeine, heroine, atropine, hyoscine, hyoscyamine, strychnine, eserine, pilocarpine, caffeine, cocaine, apomorphine, ergotin, quinine, arsenic, mercury, chloral, digitalin, nitroglycerin, alcohol, and ether.

Morphine thus employed has a wide range of usefulness, and, on account of its power to allay pain, is far more frequently given hypodermically than any other drug. The sulphate is the salt generally used. It makes a solution which is in every respect well adapted to subcutaneous administration. The ordinary dose is one-sixth to one-fourth of a grain.

Codeine is used to meet the same indications and is sometimes a desirable substitute for morphine. It is not so likely to nauseate or to constipate, though as an anodyne it is not so trustworthy. The usual dose of either the phosphate or the sulphate is one-half to one grain.

Heroine is an anodyne similar in effect to the foregoing; but, in some cases, it is better borne than either of them. The dose of the hydrochloride is gr. $\frac{1}{12}$ to gr. $\frac{1}{8}$.

Atropine, in small doses, is often combined with morphine, as it is capable of correcting, in some instances, the occasional unpleasant after-effects of the opiate when taken alone, besides possessing valuable therapeutic properties of its own. As an antidote to opium in toxic quantity it is superior to any other drug. The dose is gr. $\frac{1}{150}$ to gr. $\frac{1}{60}$. Duboisine has been recommended as an advantageous substitute for atropine in about the same doses.

Hyoscine is a valuable cerebral and spinal sedative and hypnotic in doses of gr. $\frac{1}{100}$ of the hydrobromide. It may be administered alone or combined with other anodyne and narcotic drugs. In combination with codeine its hypnotic effect in cases of cerebral excitement is most gratifying.

Hyoscyamine is closely allied in its action to atropine, but it has been found peculiarly effective in allaying maniacal excitement. The usual hypodermic dose is gr. $\frac{1}{60}$. It should be cautiously administered at first. Testimony is not lacking of its value in various forms of motor excitement—as muscular tremor, laryngismus, hiccough, etc.

Strychnine produces more decided, and often more satisfactory, results when injected subcutaneously. One-thirtieth of a grain—gradually increased when required—is a proper initial dose.

Eserine, the active principle of calabar bean, acts more promptly when given hypodermically than when administered by the stomach. The dose of the sulphate or hydrochlorate is gr. $\frac{1}{100}$ to gr. $\frac{1}{60}$. In effect, it diminishes the reflex excitability of the spinal cord.

Pilocarpine is administered in doses of one-twentieth to one-half grain. The nitrate or the hydrochloride are the salts employed. It is freely soluble in water, and acts upon the secretory and excretory glands of the body, when used hypodermically, with great promptness.

Caffeine—the sodio-benzoate—may be exhibited in one-grain doses in conditions of mental and physical depression, for nervous headaches—especially for such as are dependent upon the omission of the accustomed cup of coffee—and, in addition to atropine, in cases of opium poisoning, in acute pulmonary edema, and as a respiratory stimulant. It has also been used with some success in the treatment of neuralgia.

The hydrochloride of cocaine is used hypodermically mainly for its local anesthetic effect. Its use is not free from danger. Excessive depression of the circulation sometimes follows its administration. The dose is one-eighth to one-half of a grain, dissolved in water. The latter quantity has produced alarming symptoms, but is ordinarily safe, especially when preceded by generous alcoholic stimulation. It seems, however, that in smaller doses it reduces the frequency, but increases the force, of the pulse. More or less nausea may be experienced during its action. The extent of its anesthetic influence is very limited, probably including only the absorbing tissues which may be brought into immediate contact with the solution. It is more than likely that the drug supplied by the trade is of variable strength. Other drugs of this class, as stovaine, tropacocaine, beta-eucaine, alypin, and novocain, are used for the same purpose and in like manner, either alone or combined with adrenalin.

Apomorphine is serviceable in conditions requiring a prompt emetic, and when, from unconsciousness or from some other circumstance, deglutition is rendered impracticable. It is conspicuously useful in some cases of narcotic poisoning. In consequence, however, of its depressing influence upon the system it should be used with caution, more especially in cases of profound narcotization, in which the respiratory and cardiac movements are feeble. The usual dose is one-tenth of a grain for adults.

Ergotin is given subcutaneously to promote uterine contractions, in doses of two to five or ten grains or even in larger quantity in cases of extreme urgency. One dram of water will dissolve twenty grains of ergotin—which, in fact, is only an aqueous extract of ergot. A more concentrated solution may be made by rubbing up the purified extract with distilled water until one minim represents one grain. It should be carefully filtered to remove all solid particles. One-half grain of carbolic acid added to each ounce of the solution will prevent destructive changes, which, without it, will take place very rapidly. In the absence of the aqueous extract the fluid extract may be used. Ergotin injected under the skin is a potent remedy in metrorrhagia and is valuable also in congestion of the brain and spinal cord, in the early stages of meningitis, and in a number of uterine and other disorders. Sclerotinic acid has been prescribed as a substitute but it does not represent ergot. Adrenalin is also used as a vasoconstrictor, and pituitary extract is indorsed as an active oxytocic or ecbolic.

The sulphate of quinine—the salt of quinine commonly prescribed in this country—requires for its solution 740 parts of water, which fact is an insuperable obstacle to its satisfactory hypodermic administration. It has been proposed to dissolve the bisulphate of quinine in water by means of heat and of dilute sulphuric acid—two minims to the grain—so that one dram of the solution would contain six grains of the quinine. The solution is to be filtered immediately and a few drops of carbolic acid added to insure sterility. The official bisulphate of quinine, as commonly supplied, while freely soluble in water—one part in ten—contains an excess of acid, and, consequently, like the foregoing, is very irritating to the tissues.

Of all the preparations of quinine at present known, the hydrochloride of quinine and urea is the most available for subcutaneous injections. This double salt is made by the combination, in definite proportions, of the hydrochloride of quinine, of urea, and of hydrochloric acid. It is soluble in its weight of water at ordinary temperatures. A fifty-per-cent. solution is used with prompt effect, followed by very slight local irritation and only a transient stinging sensation at the point of insertion. It has been used as a local anesthetic in one-half to two-per-cent. solutions injected subcutaneously, or in ten to twenty-per-cent. solutions applied to mucous membranes and, on account of the remarkably prolonged anesthetic effect, it is successfully employed to "block surgical shock."

The most important field for the hypodermic use

of quinine is probably found in the pernicious types of malarial fevers, where the utmost promptness in securing its full effect is often requisite, and in the more common malarial derangements attended with gastric disturbances, which preclude its use by the mouth. The dose varies greatly according to the indications to be met. It may be stated as one to twenty grains.

The official solution of the arsenite of potassium is the form in which arsenic is generally exhibited subcutaneously. It produces less local irritation if diluted with an equal quantity of water. The dose is three minims—equivalent to about gr. $\frac{1}{5}$ of arsenous acid. It may be gradually increased to a much greater amount. Some advantages are claimed for the arsenate of sodium for hypodermic use. The official solution may be given in the same dose as the preceding preparation.

The hypodermic method is ordinarily not an available mode of using mercury in private practice, though the visible lesions of syphilis undoubtedly disappear under its use in this manner more rapidly than when it is given by the mouth. Nevertheless, from the force of circumstances, recourse to this means of treatment must be reserved for exceptional cases. The corrosive chloride dissolved in water is the favorite preparation of the drug. The dose, to commence with, may represent gr. $\frac{1}{10}$.

The great and persistent pain which accompanies and follows the hypodermic administration of chloral seriously militates against its use in this manner. A fifty-per-cent. solution in water is generally employed. A more liberal dilution of a full dose, while it diminishes the local irritation, at the same time inconveniently increases the bulk of the injection. An anodyne effect is said to follow the subcutaneous use of chloral, which is not observed when it is taken by the mouth. In cholera—both epidemic and sporadic—it yields excellent results. Bartholow reported a "very formidable case, in which there seemed but little hope: sixty grains were administered hypodermically in two hours, with the effect to stop the cramps, restore warmth, and to remove indeed all unfavorable symptoms." Chloral may be injected in combination with morphine, or with morphine and atropine. The combination constitutes a powerful anodyne hypnotic. The dose of chloral is five to ten grains or more.

Digitalin is administered to meet the indications for which digitalis is used.

Spartein sulphate in doses of gr. $\frac{1}{2}$ to gr. 1 is a useful heart tonic.

Nitroglycerin is a diffusible cardiac stimulant.

Alcoholic stimulants may be given hypodermically in the form of brandy, whiskey, or diluted alcohol, when an immediate effect is required or when administration otherwise cannot be accomplished. A syringeful may be injected.

Ether is extolled as a diffusible stimulant in conditions of collapse or of profound physical depression. It may be given in doses of fifteen to thirty minims undiluted. The addition of one to two grains of camphor to the dose increases its efficacy.

The substances used in hypodermic medication have been largely augmented of late by the addition of a long list of biological products which have been placed upon the market. The value of some of these contributions has been established, but the utility of others remains to be ascertained. Among these laboratory products, the result of unlimited enterprise stimulated by keen competition are: diphtheria and tetanus antitoxin, antidysenteric, antipneumococcic, antistreptococcic, antimeningococcic—for intradural injection—and normal serums, rabies vaccine, staphylococcic, acne, cholera, coli, catarrh, influenza, gonococcic, diphtheria, meningococcic, pertussis, plague, pneumococcic, streptococcic, scarlatina, and typhoid bacterins, tuberculin, etc., etc.

According to the claims put forward by the promotors of this class of remedies, they cover a vast field of usefulness and are applicable to a large number of morbid conditions, a few of which are suggested by the names quoted in this partial list.

An immunized serum may be antitoxic or antibacterial or both. Its properties are regulated by the process of manufacture. The former are known as antitoxins—these are the diphtheria antitoxin and the tetanus antitoxin. The latter are denominated serums, coupled with appropriate descriptive terms indicative of their character. Bacterins are properly standardized killed bacteria in physiological salt solution.

Serum and bacterin injections are used both for prophylactic and for therapeutic purposes. It is asserted that the immunizing effect of antitoxic and of antibacterial serums is immediate, but is of short duration, whereas the injection of bacterins is not followed by immediate results, but that the immunizing effect is much more prolonged, covering a period, perhaps, of months or of years. It is therefore advised that both methods be followed when time is an important element, and that bacterins be given in conjunction with serums.

Serums and bacterins composed of a number of strains of a pathogenic organism are labeled polyvalent. It is claimed that they are more efficacious in many instances than the pure cultures. The several combinations of different bacterins are designated as mixed, and are suitable to conditions of mixed infection.

The theory of serum and of bacterin therapy is based upon the idea of introducing into the circulation serums or bacterins which contain or develop so-called antibodies, the effect of which, in the case of antitoxins, is to check or to destroy the toxic products of bacterial activity, and in the case of serums and bacterins to prevent the formation of pathogenic organisms or to accomplish the destruction of those already developed.

The injection of therapeutic serum may be subcutaneous, intramuscular, or intravenous. The rapidity of action is in inverse ratio to the order of this enumeration, and the method of administration should be determined according to the urgency of the symptoms.

The strength of the solutions employed for hypodermic injections is a matter of some consequence. If too free dilution be resorted to, the mere bulk of the injection is annoying on account of the pain consequent upon distention of the tissues or upon successive punctures of the skin, which may be necessary for its introduction. If, on the other hand, the solution be too concentrated, it may prove very irritating. Then, again, it should be remembered that a few drops of the solution may remain in the nozzle and in the needle. This residuum will, of course, be of more importance if taken from five than from twenty drops. Two drops, for instance, will represent in the former case nearly one-half of the dose, which might be a serious loss, while in the latter it would be a waste of only one-tenth, and possibly be inappreciable so far as the effect of the drug is concerned.

As many of the remedies used hypodermically are concentrated poisons, accuracy of dose is necessary.

Distilled water is not essential in making the solutions; indeed, it is inferior to river, cistern, or well water, either of which will answer every requirement, if only free from visible impurities.

Strong acid and strong alkaline solutions are unfitted for hypodermic administration. The solutions should be as nearly neutral as possible and free from irritant qualities. "Metallic salts have their irritating properties diminished or removed by being combined with albumen or with an alkaline citrate or tartrate, so as to form double salts" (Brunton).

Solutions of the alkaloids undergo subtle and unknown changes when kept for a considerable time. They develop also a fungous growth —*penicillium* —a minute organism which multiplies at the expense of the alkaloid, and the solution deteriorates in proportion to the increase of this formation. The evaporation of the menstruum will also influence the strength of the solution. Therefore fresh solutions only should be employed, or, better still, they may be extemporaneously prepared from powders of known quantity, or from hypodermic tablets. Simple tablets, composed of a single drug or several combinations of different drugs, may be procured.

The use of cherry-laurel and of eucalyptus waters as menstrua for the alkaloids serves to prevent the destructive changes that render the simple aqueous solutions unstable and unreliable. The antiseptic influence of carbolic acid and of salicylic acid has been invoked for the same purpose. One to four grains of either to the ounce will not prove objectionable, and will preserve the solutions for several months. Boric acid is also employed with a like object.

The solution injected should be entirely free from solid particles. To insure this point it is well to warm the mixture before drawing it into the syringe, as heat increases the solvent action of water, and, besides, a moderately warm injection is less disagreeable to the sensations of the patient. Heat may be conveniently applied by holding the spoon containing the solution for a few seconds over a gas jet, a lamp flame, or a burning match.

The prominent advantages which accrue from the hypodermic method of exhibiting drugs consists principally in the prompt effect obtained; the opportunity which it affords to surmount the obstacles of nausea and vomiting so commonly encountered, and to overcome also any voluntary or involuntary resistance on the part of the patient, the consequence of unwillingness or inability to swallow. In many cases, too, from some idiosyncrasy of the individual, a peculiar susceptibility exists to unpleasant after-effects of certain medicinal agents when taken by the mouth. This result may, not infrequently, be moderated or obviated by the subcutaneous injection of the same remedy, and a smaller dose may be depended upon to yield given results; moreover, it is possible that a special therapeutic effect may sometimes be secured. Absorption from the subcutaneous cellular tissue is less likely to be modified by the condition of the organism than absorption from the stomach and intestines. In the alimentary canal the condition of the circulation, the presence or absence of food, the state of the lining membrane, the nervous supply, etc., influence, regulate, and determine absorption.

With a sharp needle, of not too great size and free from rust, properly managed in a suitable locality, the pain from the operation is, as a rule, insignificant. The danger of provoking inflammation either by the puncture or by the presence of the injected liquid, of the resulting cicatrices, of conveying through the medium of the syringe specific disease, and of injecting air into a vein, are all objections that have been urged against the procedure; but with the exercise of ordinary skill, prudence, and cleanliness, the risks are so remote and so improbable that they need not be seriously considered in estimating correctly the great, palpable, and immediate advantages pertaining to this accepted and indispensable therapeutic resource.

James B. Baird.

Hypodermoclysis.—By this term (derived from ὑπο, beneath, δέρμα, skin, κλύσις, a washing out) is understood the injection into the subcutaneous tissues of a large amount of saline solution with the object of supplying the body with fluid (as after profuse hemorrhage) or of flushing the kidneys and thereby aiding in the elimination of effete and toxic material. The procedure had been occasionally employed for some time by Continental physicians and a few Americans, but it did not receive much attention in this country before the appearance of a paper on the subject by Hildebrand of San Francisco. This was followed by a number of publications by Hare of Philadelphia who demonstrated the value of the method by a series of clinical experiments.

Although the procedure is of undoubted utility in certain cases, it is comparatively seldom used to-day, having been replaced by intravenous injections or rectal infusions of saline solution, which are preferred in many cases because of their superior promptness and certainty.

The chief indications for hypodermoclysis are furnished in cases in which the rectum cannot be utilized, and when there is not sufficient urgency for the intravenous route. In order to give it to best advantage several needles are used simultaneously, in the loose skin beneath the breast, and on the posterior aspects of the thighs. Small quantities only are injected, and massage should follow. In this way it is possible to repeat the operation every hour. Strict asepsis is necessary.

In order to introduce fluid in large amount under the skin one should employ an ordinary clean glass irrigating apparatus and rubber tube. In the distal end of the rubber tube is inserted a needle having a caliber about that of the ordinary antitoxin needle. The reservoir is hung about eighteen inches or two feet above the level at which the needle is inserted. The salt solution should be at about 110° F. in the reservoir, since it cools rapidly in its slow passage through the tube. Or, better still, it may be placed in a warm reservoir at the temperature of 100°, and the rubber tube may be coiled in a basin of water at the same temperature so that the fluid in it is maintained at the temperature of 100° during its flow. The skin where the needle is to be inserted should be thoroughly cleansed before the puncture is made. The most satisfactory site for the injection is the abdomen, about half-way between the navel and the anterior superior spine, or, in stout persons and in women, in the submammary region, and sometimes it may be employed on the inner side of the thighs, care being taken to avoid the great vessels. If aseptic precautions are maintained abscess practically never results, and the operation is quite painless, although some tenderness may exist in the region of the injection for a few hours after the absorption of the fluid. When it is desired to inject a considerable quantity of liquid several needles and tubes may be employed simultaneously.

An important point to be remembered in the use of hypodermoclysis is that it is not safe to infuse a greater quantity of liquid than one dram to each pound of body weight in each fifteen minutes; as, if this amount is exceeded, the kidneys cannot excrete the liquid rapidly enough. Hypodermoclysis is contraindicated in edema of the lungs due to either cardiac or renal disease, in cases of chronic bronchitis with excessive secretion of mucus and fluid, and in persons with very high blood pressure.

Edward Preble.

Hypoglossal Nerve.—Anatomy.—The hypoglossal nerves (XII pair) are the chief motor nerves of the tongue. Through collaterals they also send fibers to the sternohyoid and sternothyroid muscles. The chief physiological functions by symmetrical innervation are as follows: The genioglossus muscle moves the tongue forward and down; the hyoglossus muscle moves the tongue back and up; the styloglossus muscle moves the base of the tongue up and back. In asymmetrical innervation, *i.e.* loss on one side, the combined action of these three muscles causes the tongue to deviate in toto to the paralyzed side.

Affection of the longitudinal muscle by symmetrical

innervation causes a shortening of the tongue in its long direction, this pulling the tongue either up or down. By asymmetrical innervation, the anterior portion of the tongue is pushed to the paralyzed side. Any loss of the function of the branch which innervates the transverse muscles brings about a shortening of the tongue laterally whereas symmetrical affection of the vertical muscles produces a flattening of the tongue.

The geniohyoid raises the hyoid bone, pulling it forward when the lower jaw is fixed, or pulls the lower jaw down when the hyoid bone is fixed. The sternohyoid and the thyrohyoid pull the hyoid bone.

The nuclei of the hypoglosuss lie in the lower two-thirds of the medulla, stretching as far down as the pyramidal crossing ventrally from the central canal of the mid line. At least ten to fifteen bundles pass from each hypoglossal nucleus between the pyramidal tracts to the olive, and join together for a short time within the hypoglossal canal at the orifice of which the hypoglossal vein, which is in connection with the occipital sinus, surrounds it. The canal is small and short—less than one-half inch—lying close to the occipitoatlantoid articulation at a place where fracture of the base of the skull is very apt to affect it.

At its exit from the skull the hypoglossus lies median and dorsal to the vagus and to the external jugular vein, proceeds laterally, passes beneath the stylohyoid muscle and the posterior belly of the digastric, splits into its various branches and innervates the muscles already mentioned.

Anastomoses with the ganglion nodosum, superior cervical ganglion, the lingual, and first and second cervical nerves take place. A special branch, the ansa hypoglossal, is formed by anastomoses of the descending branch of the hypoglossal and branches from the second and third cervical nerves.

The supranuclear pathways are followed with considerable difficulty. In the cerebral peduncles they lie in the center somewhat median from the facial; within the internal capsule they lie at the knee; the cortical stations lie in the lower portion of the central convolution. The supranuclear pathways decussate freely.

Peripheral lesions of the hypoglossal are the result usually of mechanical causes, resulting either from fracture of the base of the skull, from tumors, direct injury or tuberculosis, or dislocation of the upper cervical vertebræ. Cerebrospinal syphilis, of the base particularly, is a not infrequent cause of peripheral palsies, while poisoning from lead, arsenic, alcohol, carbon monoxide may cause peripheral lesions.

Nuclear and supranuclear affections of the hypoglossal are due to hemorrhage (thrombus, embolus) within the medulla (inferior cerebellar artery), vertebral, basilar, poliomyelitis, tumors, syphilis, syringomyelia, and multiple sclerosis. These are the most frequent causes of nuclear and supranuclear lesions of these nerves.

Clinical.—The most frequent lesions of the hypoglossal are peripheral. There is atony of the longitudinal muscles of the paralyzed side, and when the tongue lies quiet in the mouth it deviates slightly to the non-paralyzed side. The base of the tongue usually rises higher on the paralyzed side than on the sound side as a result of atony of the hypoglossus muscle. Movements of the tongue are diminished so that it becomes difficult to remove food which lies between the teeth and the muscles of the mouth, and it becomes difficult for the patient to direct the tongue to the teeth on the paralyzed side. On thrusting the tongue out, it deviates to the sound side. Speech disturbances are present, especially in articulating the labials and linguals.

In long-standing disease, atrophies develop, with fibrillary twitchings and tremors and pronounced irregularities in the nerves of the muscles. Electrical stimulation shows reaction of degeneration.

In bilateral paralysis speech disturbances are more marked, chewing and swallowing are rendered difficult, and the movements of the tongue are markedly diminished in all directions.

In hysterical tongue paralyses, which are by no means uncommon, resistance to passive motion of the tongue is seen. There are no electrical changes, and the speech disorder is apt to be obvious.

In nuclear palsies, atrophy and fibrillary twitching are marked, the speech disturbances are pronounced, the chief characteristic being what is termed "hot potato" speech, the patient speaking as though he had a hot morsel in the mouth. Paralyses are usually wide spread. Reaction of degeneration is also present.

Supranuclear palsies, such as occur in hemiplegia, involve the muscles as a whole, cause deviation of the tongue to the paralyzed side, and other signs of hemiplegia are present. Pseudobulbar palsy is a characteristic syndrome. Wilson's lenticular syndrome also causes dysarthric speech disturbances from central blocking the hypoglossal pathways. Isolated cortical spasm of the hypoglossal is sometimes seen.

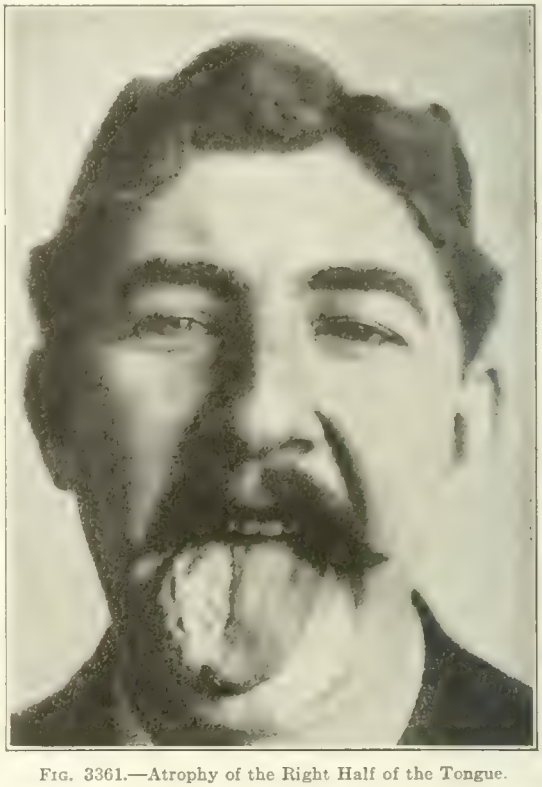


Fig. 3361.—Atrophy of the Right Half of the Tongue.

Psychogenetic hypoglossal disturbances (hysterical, compulsive, psychotic) are by no means rare. These consist of tongue tics, of constant tongue movements, stammering, swallowing movements, such as are seen in hysteria, in cases of dementia precox, compulsion neuroses and in various paranoid types of thinking.

The *treatment* of hypoglossal disturbances varies according to the cause. A speech disturbance due to basal syphilis needs salvarsan and iodides, one with conversion mechanisms requires psychoanalysis.

Smith Ely Jelliffe.

Hypophosphites.—I. General Medical Properties of the Hypophosphites.—Physiologically, salts of hypophosphorous acid are simply bland saline representatives of their respective bases, and produce no special effect whatsoever, due to the hypophos-

phorous acid of their composition. What place they hold in medicine is due to theoretical considerations only. The idea has been that because these salts contain phosphorus in a comparatively low state of oxidation, they will affect the system after the manner of phosphorus itself, and, especially, will yield phosphorus in such chemical combination as to be assimilable for the nutrition of nerve tissues. Clinical experience, however, has failed on the one hand to get the expected results, while on the other it has shown that nearly all of a dose of a hypophosphite, swallowed, reappears in the urine unchanged. Those who prescribe these salts, do so in cases of neuralgia and of nerve exhaustion or malnutrition generally, and in phthisis.

With the exception of the potassium salt the hypophosphites are harmless, and they are, with manufacturing pharmaceutists, favorite ingredients of emulsions of cod-liver oil.

II. The Hypophosphites Used in Medicine.—The hypophosphites official in the United States Pharmacopœia are the iron, potassium, sodium, calcium and manganese salts. Ferric hypophosphite will be found treated of under *Ferrum*.

Potassium Hypophosphite, KH_2PO_2. The salt is official in the United States Pharmacopœia as *Potassii Hypophosphis*, Potassium Hypophosphite. It occurs in "white, opaque, hexagonal plates, or crystalline masses, or a granular powder; odorless, and having a pungent, saline taste; very deliquescent. Soluble in about 0.5 part of water, and in 7 parts of alcohol at 25° C. (77° F.); in 0.3 part of boiling water, and in 3.6 parts of boiling alcohol; insoluble in ether" (U. S. P.). If triturated or heated with an oxidizing agent, such as a nitrate, the mixture will explode. Because of deliquescence, the salt must be kept in well-stoppered bottles.

Potassium hypophosphite follows the rule of potassic salts of being irritant in large concentrated dosage, but in therapeutic doses it is locally bland enough. Again, because a potassic salt, it may tend to induce retrograde metamorphosis of lowly organized material, and hence lead to softening of cheesy deposits in the lungs. This particular hypophosphite is therefore, theoretically at least, not without a possible dangerous tendency in phthisis. The salt is administered in solution, aqueous or syrupy, in doses of about 7½ grains (0.50 gm.) three times a day. A convenient form of giving it is in the official *syrup of hypophosphites* (see below).

Sodium Hypophosphite, $NaH_2PO_2+H_2O$. The salt is official in the United States Pharmacopœia as *Sodii Hypophosphis*, Sodium Hypophosphite. It occurs in "small, colorless, transparent, rectangular plates of a pearly luster, or a white granular powder, odorless, and having a bitterish-sweet, saline taste. Very deliquescent on exposure to moist air. Soluble in about 1 part of water, and in 25 parts of alcohol at 25° C. (77° F.); in 0.12 part of boiling water, and in 1 part of boiling alcohol, slightly soluble in absolute alcohol, insoluble in ether" (U. S. P.). Like the potassium salt, this also will explode on trituration and with an oxidizing agent, and must be kept in well-stoppered bottles.

This sodium salt is a generally serviceable and permissible hypophosphite, having, as usual with compounds of sodium, no active individuality due to the basic radical. It may be given in the same manner as the potassium salts; the dose is double that of potassium hypophosphite.

Calcium Hypophosphite, $Ca(H_2PO_2)_2$. The salt is official in the United States Pharmacopœia as *Calcii Hypophosphis*, Calcium Hypophosphite. It occurs as "colorless, transparent, monoclinic prisms, or small, lustrous scales, or a white, crystalline powder, odorless, having a nauseous, bitter taste, and permanent in the air. Soluble in 6.5 parts of water at 25° C. (77° F.), and in 6 parts of boiling water; insoluble in alcohol" (U. S. P.).

Being a salt of lime, which salt is assumed to have a reconstituent tendency in phthisical conditions, this hypophosphite is theoretically the one to be preferred for administration in consumption. It is also the one best borne when the stomach and bowels are irritable, as so often happens in the disease mentioned. The salt is given in the same manner and dose as the potassium salt.

Manganese Hypophosphite, $Mn(H_2PO_2)_2+H_2O$. This salt is official in the United States Pharmacopœia as *Mangani Hypophosphis*, Manganese Hypophosphite. It occurs as "a pink crystalline powder, odorless, and nearly tasteless; permanent in the air. Soluble in 6.6 parts of water at 25° C. (77° F.), and in 6 parts of boiling water; almost insoluble in alcohol" (U. S. P.). The dose is 3 grains (0.20 gm.).

The following pharmaceutical preparations of the hypophosphites are official in the United States Pharmacopœia; *Syrupus Hypophosphitum*, Syrup of Hypophosphites. This is an aqueous solution of potassium, sodium, and calcium hypophosphites (wherein the latter salt has been made fully to dissolve by the addition of a little hypophosphorous acid), made into a syrup by the addition of sugar, and flavored with spirit of lemon. By weight the preparation contains sixty-five per cent. of sugar, and, of the hypophosphites, 4.5 per cent. of the calcium salt, and 1.5 per cent. each of the potassium and sodium. By measure 4 c.c. (fl. ʒ i) contains about 0.18 gm. (gr. iij.) of the calcium hypophosphite, and 0.06 gm. (gr. i.) each of the potassium and sodium salts. This syrup forms a convenient preparation for prescription, and may be ordered in doses of from one to two or three teaspoonfuls, several times a day. *Syrupus Hypophosphitum Compositus*, Compound Syrup of Hypophosphites. This preparation contains 3.5 per cent. of calcium hypophosphite, 1.5 per cent. each of the sodium and potassium hypophosphites, 0.2 per cent. of ferric hypophosphite, 0.2 per cent. of manganese hypophosphite, 0.1 per cent. of quinine, 0.3 per cent. of sodium citrate, 1.5 per cent. of dilute hypophosphorous acid, and 77 per cent. of sugar. This syrup forms a convenient combination of hypophosphites with a chalybeate, and may be given, where such combination is indicated, in doses the same as those of the simple syrup.

Edward Curtis.
R. J. E. Scott.

Hypophysis Cerebri.—*Synonyms:* Pituitary Gland; Ger., Hypophyse; Fr., Glande or Corps Pituitaire; Ital., Glandola Pituitaria; Span., Glandula Pituitaria.

Vesalius was the first to describe this organ, and in his "De Corporis Humani Fabrica" (1553) he calls it the "gland pituitam excipiens" due to the mistaken idea that this organ secreted the nasal mucus (pituita). Soemmering (1778) described it more fully and was the first to call the gland the hypophysis cerebri. The terms hypophysis and pituitary are often used as synonyms. For clearness Collina (1898) has suggested calling the anterior or epithelial lobe the pituitary gland, the posterior or neural lobe the processus infundibuli, and the entire organ the hypophysis. Unfortunately this excellent idea has not been generally adopted.

That the pituitary does not secrete mucus was first shown by E. Schneider (1660–1664). He proved that the cribriform plate showed foramina only when it was dry and not when it was covered with fresh mucous membrane. He also demonstrated that the gland was relatively much smaller in man than in animals. A later view shared by Willis, Sylvius, Boerhaave, and Monroe, was that the hypophysis secreted cerebrospinal fluid which escaped into the ventricles, and even as late as 1847 Magendie thought that the hypophysis was an organ similar to a lymph node, collecting the lymph of the brain and transferring it to the circulation. Wenzel in 1810 believed that the

collection of colloid in the hypophysis was the cause of epilepsy and other tetanic conditions, and Engel in 1839 suggested that the hypophysis was correlated under pathological relationship with the thyroid gland as a sexual organ. Liégeois in 1860 classified the hypophysis in the group of the so-called ductless or blood-vessel glands and demonstrated its histological structure, thinking that it was an organ for blood formation. It was only in 1867 that Peremeschko gave the first accurate description of the structure of the hypophysis. He showed that instead of the generally assumed anterior and posterior lobes, the organ could be divided into, first, an anterior grayish-red portion; second, the hypophyseal cavity; third, the white medullary layer; and fourth, the grayish-white nervous posterior portion of the gland. Further studies by Herring, Tilney, and others have shown that the gland is even more complex.

It was not until 1886 that it was recognized that this organ had any relation to disease. In that year Marie published his article on acromegaly and first showed that the occurrence of tumors in the gland was correlated with this disease, though the clinical picture of acromegaly had been long known. Minkowski in 1887 called attention to the fact that in all accurately investigated cases of acromegaly there was not only more or less well-marked hypertrophy of all the inner organs, but especially striking increase in size of the hypophysis. The work of these two investigators gave great impetus to the study of the physiology and pathology of the hypophysis, and Marie also demonstrated the conditions which resulted from the extirpation of the gland. Oliver and Schaefer, however, in 1894 made a great advance when they showed that a watery extract of the hypophysis had certain well-characterized physiological actions, and recent investigators following in their footsteps have attempted to show that the various portions of the hypophysis which may be distinguished morphologically have also different physiological actions.

Anatomy.—The hypophysis is a small oval body resting in the sella turcica, or pituitary fossa, of the sphenoid bone. It is connected by a narrow strand of tissue, the infundibular stalk, with the base of the brain just posterior to the optic chiasm. The lateral boundaries of the hypophysis are formed by the walls of the sinus cavernosus. On the anterior and posterior surfaces small venous branches form a circular pattern about the infundibulum, the circle of Ridley. This also separates the gland from the internal carotid artery. The afferent vascular supply of the hypophysis comes from the circle of Willis which sends out a series of small arterial branches penetrating into the organ. The venous flow is carried off by small veins which empty into the circular sinus of Ridley. The average weight of the hypophysis in persons from thirty to forty years of age is about 59 centigrams. An average of 66 centigrams in men and of 73 centigrams in women has been noted by Caselli, but these figures cannot be considered as representing the normal since some of his observations were made on insane patients and in cases of insanity the hypophysis is apt to be enlarged. Up to the fortieth year in normal persons there is a gradual increase in the weight of the gland, and after that a slow decrease. In women who have not borne children the weight of the organ is approximately the same as in the male, and even the maximum noted in a nullipara (75 centigrams) is less than the average noted in a large series of primiparæ (85 centigrams). Toward the end of pregnancy the average weight of the gland is 105 centigrams in the multipara, which is considerably more than that noted in the primipara. At the termination of pregnancy there is a diminution in weight, with a further and greater increase if another pregnancy occurs. Maximum weights of 165 centigrams in a multipara and 110 centigrams in a primipara have been observed. The increase in the size of the hypophysis takes place almost entirely in the lateral and vertical directions, not in the anteroposterior. In the adult male the dimensions are about 14.4 millimeters in the transverse axis, 21.5 millimeters in thickness, and 5.5 millimeters in the vertical direction. The color of the organ is dark brown or bluish red. Even macroscopically it is possible to make out two portions of the hypophysis, an anterior kidney-shaped part which is concave posteriorly, pale yellow or grayish red, and rather firm. This corresponds to the epithelial or glandular portion of the hypophysis, or, as it has been called, the pre-hypophysis. The posterior portion is smaller, roundish, white, and much softer than the anterior. It contains the nervous and neurofibrillar portions. This is the true hypophysis or neurohypophysis and lies in the cavity of the kidney-shaped

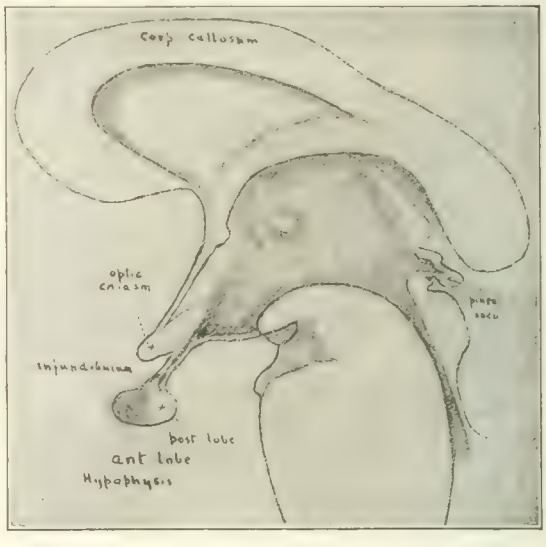


Fig. 3362.—Vertical Section of Base of Brain, showing the position of the hypophysis and its relation to the floor of the fourth ventricle and the optic chiasm.

anterior part. Both of these structures are held together by loose connective tissue and enclosed in a common capsule. The organ is united with the base of the brain by a stalk extending up to the funnel-shaped infundibulum which forms a protrusion from the floor of the third ventricle. As a rule, in man there is no canal remaining, the whole peduncle forming a solid structure; but in some animals it remains open; and occasionally in certain diseases of the hypophysis the canal may again open in man and connect with the ventricles of the brain.

A more careful study of the relations of the various structures shows that the pars intermedia, which lies between the anterior and posterior lobes and surrounds the infundibular process, may be divided into two portions the pars tuberalis and the pars infundibularis (Fig. 3362). These two structures have been shown by Tilney to possess marked morphological and histological differences.

Embryology.—The pituitary gland is developed from two rudiments, one arising from the floor of the forebrain (prosencephalon) just behind the optic recess, and the other from the pharynx. The latter is the so-called Rathke's pouch, which is a protrusion of the buccal ectoderm from the roof of the stomodeum beginning at about the fourth week in the human embryo. This forms a flattened cleft which projects toward the base of the forebrain and is covered with several layers of cylindrical epithelium. A little later this duct is separated from the mouth cavity and

remains as a small blind channel, which later becomes solid owing to the growth of the bone at the base of the skull separating it from the roof of the pharynx. During the latter half of the second month of embryonic life small buds are formed from this hypophyseal duct which pass out into the surrounding vascular connective tissue and are ultimately cut off from the hypophyseal cavity and remain as isolated structures which ultimately form the anterior portion of the hypophysis. A part of the buccal epithelium does not undergo this change into glandular structure, but remains as small areas of flat epithelium, which explains the occasional occurrence in the hypophysis of quamous-cell carcinomata. (Fig. 3363.) As a rule, in normal adult skulls there is no canal left in the bone;

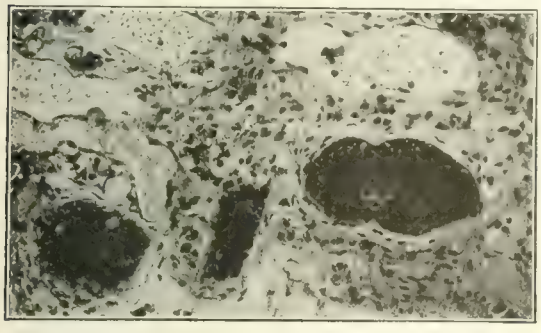


Fig. 3363.—Epithelial Remnants at the Periphery of the Pars Nervosa.

but in newly born children, especially those with other congenital defects, a canal is occasionally found in the roof of the pharynx. Small fragments of the duct may also be left *in situ*, forming accessory hypophyses which are distributed along the space between the base of the brain and the roof of the pharynx. Some observers, in fact, assert that in all cases there are small remnants of hypophyseal tissue left under the mucous membrane and that these go to form the tumors which are occasionally found in the vault of the pharynx resembling the adenomata which occur in the gland itself in the course of the disease known as acromegaly. At about the same time that the buccal projection is forming, a pouching of the floor plate of the forebrain also occurs; and the small sac thus formed meets the epithelial canal and uniting with it in a loose capsule makes up the ultimate organ known as the hypophysis or the pituitary gland.

Histology.—The structures of the anterior and posterior lobes of the hypophysis are so radically different that unless they were united it would not be supposed that they came from the same organ. The anterior portion consists of a meshwork of connective tissue, cellular strands or clumps, and capillaries having the character of sinusoids. The cells may be divided into three classes: the first two comprise the so-called chromophile cells, and the third the chromophobe cells, or chief cells, as they are also called. The first variety of chromophile cells is a round or polyhedral structure with a practically homogeneous cell body, though occasionally a fine granulation can be noted. The cell bodies stain strongly with eosin; hence the name eosinophile cells. The other type of chromophile cells is regular and somewhat larger in structure, stains very darkly with hematoxylin, and shows coarse granules in the cell protoplasm; these are called basophile cells. The chromophobe cells show irregular boundaries and a very faintly staining protoplasm with a large round or irregular nucleus containing a well-marked chromatin network. The distribution of these three varieties of cells is not at all constant. The main collection of the eosinophile cells may be in the posterior portion of the anterior lobe, while the basophile cells lie chiefly anterior, with the chief cells scattered among them, but this distribution though frequently met with, is not at all constant.

In the first years of life the chromophile cells do not appear in very large numbers, but about the age of puberty they increase rapidly; and from then on regularly up to the fortieth year; after that there is a moderate diminution in the number of eosinophile and basophile cells. During pregnancy, on the other hand, the chief cells or chromophobe cells increase greatly in number, and to a certain extent change their histological character; so that some observers have spoken of these new types as the cells of pregnancy. Even after delivery a certain increased number of chief cells remains, and this accounts for the greater volume and weight of the hypophysis in women who have borne children. The question whether the specific granules of the chromophile cells of the hypophysis represent a secretory product or not, is as yet unsettled. Many authors, among them Benda, consider that this is the case, and go a step further in concluding that the chromophobe cells and the chromophile cells are merely different forms of the same cell, and not different species. But Erdheim believes that while the

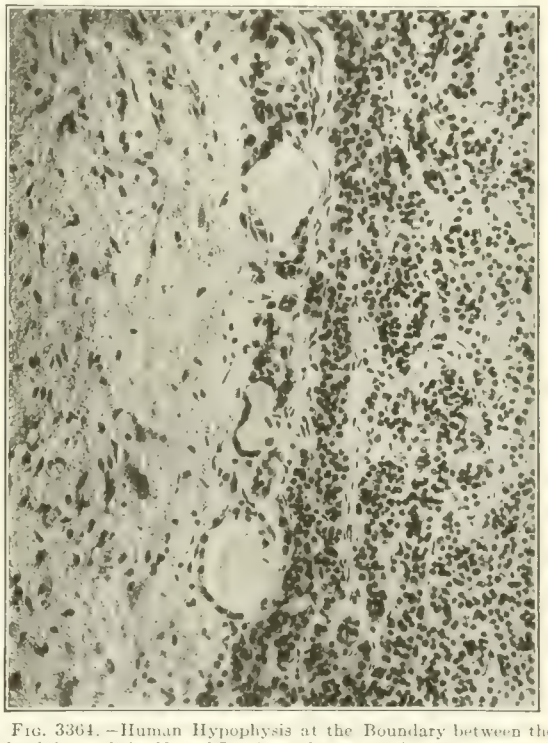


Fig. 3364.—Human Hypophysis at the Boundary between the Glandular and the Neural Portions, the so-called Pars Intermedia. Three colloid vesicle are shown in the figure.

chromophile cells may well be derivatives of the chief cells, yet the eosinophile and basophile cells are distinct from each other, especially because tumors can be found containing chiefly one or the other type of cells. Other authors think that the peculiar granules have nothing to do with the secretion, but that this is wholly contained in a colloid substance which is found in a certain group of cells about the posterior portion of the anterior lobe, probably derived from the embryonal hypophyseal cavity which is present in man up to about the tenth year as a long narrow space lined with a single layer of cylindrical ciliated epithelium, or occasionally with two or three thicknesses of cubical epithelium, and usually containing a mass

which stains a pale blue with hematoxylin. The deposits of this specific colloid substance are found not only in the posterior portion of the lobe, but in cells which lie along the hypophyseal ducts or cavity. These colloid masses suggest very strongly the morphological picture of the follicles of the thyroid gland. The wall of the follicles consists of cubical, poorly staining cells with large nuclei, the lumen is filled with an amorphous mass which often takes a reddish color

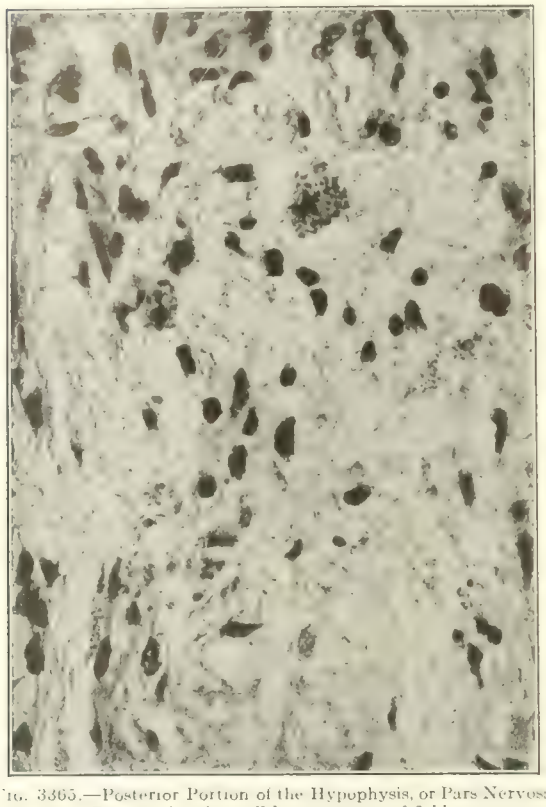


Fig. 3365.—Posterior Portion of the Hypophysis, or Pars Nervosa
Pigment-bearing cell in upper part of field.

with eosin, though some stain, as does the thyroid colloid, a more or less dark reddish blue or pure blue color. These structures lie in the so-called pars infundibularis of the pars intermedia, and are much better developed in animals than in man. Unlike the thyroid colloid, the colloidal substance in the hypophysis contains no iodine. Not all of this colloidal substance is contained, however, in alveoli or follicles; a good deal of it may be interfollicular, and there seems to be very little question at the present time that this substance passes up the loose tissue of the hypophyseal stalk and may under certain conditions pass into the cerebrospinal fluid of the ventricles. Some of Cushing's experimental work points strongly in this direction. In animals the amount of this colloid substance is increased after thyroidectomy.

The posterior lobe or pars nervosa lies in a depression in the posterior portion of the anterior lobe. Histologically it consists of a loose stroma in which are scattered the connective-tissue elements and glia cells, the latter predominating. There seems to be no question that true nerve cells and nerve filaments are present in the nervous portions of this organ. Scattered throughout the posterior lobe is a peculiar pigment which lies chiefly in the glia fibers and to a certain amount in the glia and ependyma cells. It is not fat nor a lipochrome, but is probably a metabolic product of the specific gland secretion. It gives no iron reaction, is not soluble in any of the ordinary reagents, and does not stain with osmic acid with the fat dyes, or with hematoxylin. It appears first about the tenth month after birth and more constantly after the fourth year.

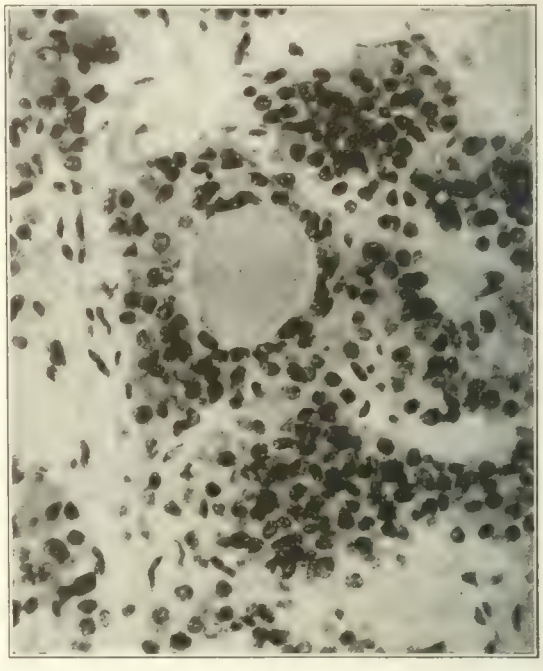


Fig. 3366.—Colloid Body in the Anterior Lobe of the Hypophysis.

Pathological Anatomy.—Because of the peculiar and intimate relationship of the hypophysis with the base of the brain, lesions of the latter organ are apt to involve this gland. These secondary invasions may or may not be marked enough to produce symptoms; but usually before serious alteration occurs in the pituitary, the primary lesion at the base of the brain has produced its effect and either caused the death of the patient or masked the symptoms caused by the pituitary lesion.

Developmental Anomalies.—In addition to the regularly occurring pharyngeal hypophysis, accessory deposits of gland substance may occur in the roof of the pharynx, in the craniopharyngeal duct, in the body of the sphenoid bone, and in the sella turcica, and under these circumstances the gland may or may not be completely developed in its usual site. Congenital hypoplasia is frequently met with in cretins and dwarfs. The portion of the gland chiefly affected is the anterior lobe; this may be almost entirely atrophied. A generalized atrophy of the gland often appears in old age, and is also seen in myxedema, exophthalmic goiter, and arteriosclerosis, with lesions chiefly in the anterior lobe. The chromophilic cells disappear first under these circumstances. Various degenerations are found in the pituitary which may be present in atrophic, normal, or hyperplastic glands. Pigmentation, coagulation necrosis, and hyaline degeneration are often seen, especially in arteriosclerotic ischemias. In diphtheria, toxic necroses of the gland have been described. Cysts are occasionally found, and occasionally also psammomatous concretions are present. Hyperemic conditions due to ectasia of the veins, even causing an angiomatous condition, may occur. Hemorrhages occur in endarteritis and in diseases affecting the blood, such as purpura hæmorrhagica and pernicious anemia. Ischemic necroses are found,

especially in extensive arteriosclerosis and syphilitic arteritis. Tuberculous and syphilitic nodules are met with only very rarely. Primary acute inflammation is almost unknown, though extension from a basal meningitis is not infrequent; the lesion rarely involves the substance of the gland itself owing to the very complete protection exerted by the dural capsule which surrounds it. Secondary involvement of the pituitary may occur with abscesses in the

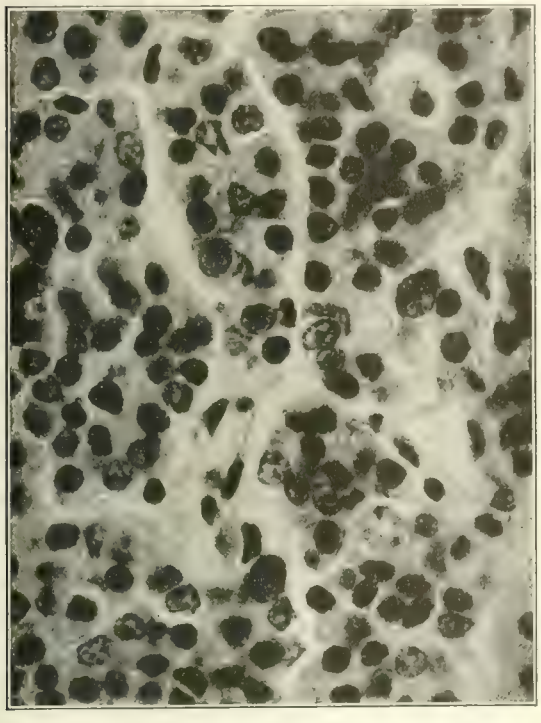


Fig. 3367.—Anterior Portion of the Hypophysis. The portion containing chiefly basophile cells.

pharyngeal vault. A physiological hypertrophy of the organ occurs in pregnancy. Hyperplasias are also seen after castration both in males and females and also in connection with atrophy of the thyroid gland in myxedema.

Tumors.—The most important alteration of the hypophysis is the formation of adenomata. These may be composed of either the eosinophile or the basophile cells, and hence form eosinophile or basophile adenomata. Small adenomatous nodules are frequently present in individuals over forty years of age. The larger adenomata show a very atypical structure and are frequently considered as sarcomata, Many of these tumors break through the capsule. and may involve the bone and the neighboring portions of the brain. The most common type is the tumor of the eosinophile cells, a form which frequently is accompanied by acromegaly, while other forms of tumor occurring in this gland do not cause the disease. The purely epithelial tumors, mostly squamous in type, are chiefly derived from remnants of the hypophyseal sac and duct; cystic tumors containing colloid spaces have been found chiefly in the pars intermedia; and complex tumors containing squamous epithelium, cartilage, and bone have been described; these are teratoid in their nature and can be explained only by germinal displacement during embryonic life. Lipoma and fibroma have been seen and in some cases remnants of chorda tissue have been discovered in these tumors. Cholesteatomata have been seen; fibromata and sarcomata are rare and usually occur in the posterior lobe. An echinococcus cyst of the hypophysis has been noted.

Chemistry.—But little is yet known as to the chemical nature of the substances in the hypophysis which cause various physiological phenomena in the body. We know only that the extract from the gland contains a considerable amount of phosphorus and lime, and, after iodine has been administered, may contain a quantity of this substance; unless such medication has been previously exhibited no iodine is found in the gland. Crystallizable bodies have been obtained from the hypophysis by various methods, some of them showing to a high degree the physiological action of watery extracts of the whole gland. In recent years a considerable number of commercial products have appeared on the market. Pituitrin is one which contains "a twenty per cent. extract of the posterior lobe of the hypophysis to which some chloretone has been added as a preservative." Pituglandol is "a ten per cent. extract of the infundibular portion of the gland." Vaporole is "a twenty per cent. extract of the posterior lobe and the pars intermedia of the hypophysis of the ox." These fluids can be sterilized by boiling, as they contain no albumin. There is also on the market a crystalline product which is said to contain in highly concentrated form all of the important physiological activities of the gland. None of these products is especially toxic, though after intravenous injection of large quantities, cardiac paralysis and edema of the lungs have been seen in man. It is

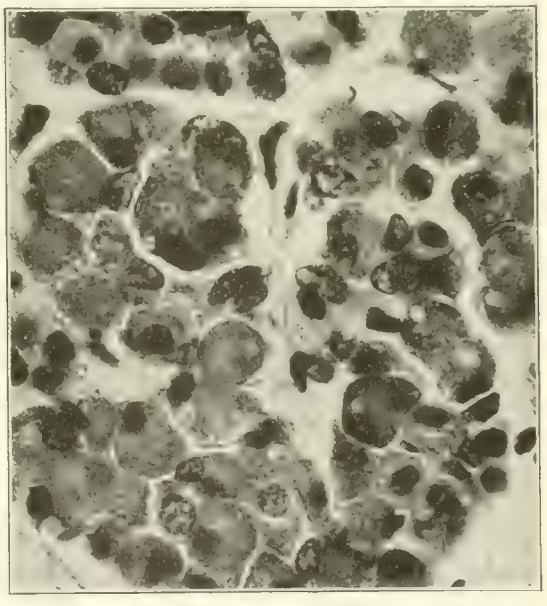


Fig. 3368.—Anterior Portion of the Hypophysis. The portion containing chiefly eosinophile cells.

said that anaphylaxis may be induced by spaced injection so that care should be taken in the administration of the drug to give several doses within a few days, and not to delay the second injection for ten days or two weeks. Repeated doses in animals have caused a hypertension and hypertrophy of the heart as well as hemorrhages in the intestines and kidney.

Physiological Action of Extracts of the Hypophysis.—As was first shown by Oliver and Schaefer, watery extracts of the hypophysis when injected intravenously, have the power of raising blood pressure, the pressure remaining high for a longer time than after injections of extracts of the adrenal gland.

The increase in pressure is due both to contraction of the vessel and to increased activity of the heart, and is entirely independent of the nervous system, as can be demonstrated by perfusion experiments. Howell showed shortly after the publication of Schaefer's results that this power of raising the blood pressure was a function of the posterior lobe, and more recent investigations have demonstrated that while the extreme posterior portion or pars nervosa has no action, the pars intermedia is the source of the active substance. A second injection, given shortly after the blood pressure has risen, does not induce an additional rise, but, on the contrary, often causes a fall. This effect, however, is lost shortly, and an injection the

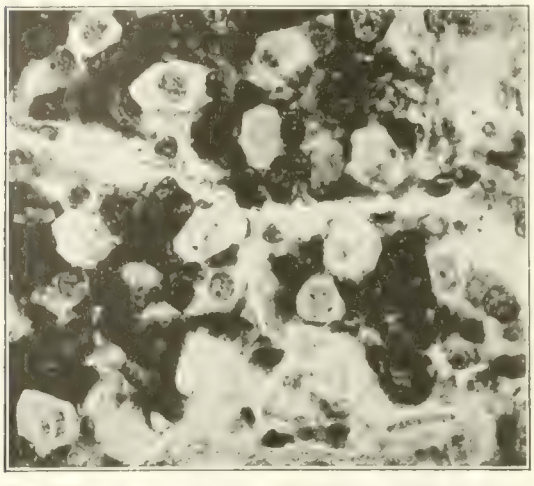


Fig. 3369. Glandular Portion of the Hypophysis. The cells in the field are the very deeply staining basophile cells, and the faintly staining chromophobe, or chief cells, which appear as clear spaces with distinct nuclei against the darker background of the eosinophile cells.

following day will cause a rise again. Extracts from the anterior lobe of the hypophysis, as a rule, effect a fall in blood pressure, but this power is not constant. The localization of the action is on the vessels themselves, as just stated; but Howell has shown that while the hypophyseal extract has the same action as adrenalin on the carotid, mesenteric, and femoral arteries, causing contraction of all of these, its effect on the vessels of the heart and kidney is exactly opposite to that of adrenalin. Thus, the coronary arteries, which are dilated by adrenalin, are contracted by extracts of the pituitary body, and the latter causes a dilatation of the peripheral portion of the renal artery and a contraction of the proximal portion. Pituitary extract causes also a strengthening and slowing of the heart beat, a part of this action being due to central stimulation of the inhibitory cardiac nerves, and a part to direct action on the musculature of the heart. Contraction of the musculature of the urinary bladder and of the uterus is also caused by the extracts; their action on the uterus of a virgin guinea-pig being so characteristic that the potency of various preparations can be determined by testing them on a strip of muscle from this organ suspended in warm Ringer's or Locke's solution (Roth). Another effect of the extracts is to alter the rhythmic contraction of the intestines, so that at first there is diminution, and later a great increase in the peristaltic movements. An increase in the flow of urine is also frequently observed after the administration of hypophyseal extracts, the action being, so far as is now known, not only on the vessels, but also on the glandular structures of the kidney. The secretion of milk in the lactating breast is stimulated by the administration of pituitrin; and, finally, this also causes an increase in the general metabolism of the body with a rise in the consumption of oxygen and in the production of carbon dioxide.

The therapeutic use of hypophyseal extract has become very general, especially as the stimulating power of the drug upon the pregnant uterus has proved useful in many cases. It should be used only after the cervix is well dilated, as it causes extreme and long-continued contractions which might result in serious difficulty if the cervix were not sufficiently softened to permit of delivery of the child. In gynecological practice, also, it is used as a hemostatic to check hemorrhage from the uterus. It has unquestionably some effect in causing freer peristalsis and, under special operative conditions, has been employed for this purpose. Its power of raising the blood pressure and stimulating contraction of the heart has been useful in conditions of collapse. As a diuretic it has been employed but has no special value. In addition, it has been used in some of the nutritional conditions in which there is evidently a hypopituitarism, as shown by the increase in the fat of the body and the lack of development of the secondary sexual characteristics.

Acromegaly.—This disease, which was first recognized by Pierre Marie in 1886, is characterized by an enlargement of the bones and soft parts of the face and extremities, and occasionally also of the internal organs. The symptoms are headache, muscular weakness, a loss of sexual activity, glycosuria, presumably due to pressure on the posterior lobe of the hypophysis, and a general failure of mental powers, probably correlated with the pressure which the growth exerts on the brain. In all the published cases of acromegaly a tumor of the hypophysis has been present, and though many of these neoplasms have been called sarcomata, in all probability this is due to a lack of recognition of the peculiar anatomy of the gland. According to B. Fischer, all such tumors occurring in acromegaly belong to the true adenomata. The cells which form these adenomata are usually of the eosinophile type, though tumors largely composed of basophile cells have been seen; the granules, however, are often less definite than in the cells of the normal gland. Occasionally an adenomatous growth may develop at a site apart from the gland. Erdheim has described one case in which the tumor was situated in the body of the sphenoid bone, and other cases are on record in which the enlargement was chiefly in the pharyngeal remnant of the hypophysis. Persistence of the thymus gland is not infrequently observed in connection with acromegaly and an atrophy of the thyroid is also to be noticed. Even more frequent than the changes in the two glands mentioned above are atrophy of the testicle with changes in the epithelium of the germinal tubules and the interstitial cells of Leydig in men, and a cessation of the formation of ova in the ovary with ultimate atrophy of the primordial follicles in women. In connection with these changes there is also very frequently noticed an obliteration of the secondary sexual characteristics. Hyperplasia of the suprarenal gland is not infrequent. The exact condition which underlies the disease is not as yet completely determined. Whether the changes in the sexual organs or in the thymus and thyroid have anything to do with the production of hypersecretion from the hypophysis or with the growth of the adenomatous masses found therein, is not as yet settled; but it is evident from what is now known of the disease that it cannot be considered as due wholly to the changes in the pituitary gland, but that it is correlated with changes in the other glands of internal secretion. Acromegaly may, therefore, be fairly considered as belonging to the group of polyglandular diseases. The very favorable results which have been noted following the partial extirpation of a tumor of the

anterior lobe of the hypophysis show, however, that this is the most important gland in the production of the symptom complex. For further clinical details see article on *Acromegaly*.

Gigantism.—Another form of disease, which is correlated with acromegaly, yet in which other factors also dominate the picture, is gigantism. In this there is evidently a hypersecretion of the hypophysis, a primary atrophy of the genital glands, and, probably in addition in some cases, a hyperactivity of the thyroid. The condition is actually an anomaly of the growth of bone, which leads to a body length exceeding the average of the race. *X*-ray examinations of the skeleton show that the epiphyseal junction may remain uncalcified during the progress of growth and that there is also an hypertrophy of the bony substance of the long bones. The spinal column is often kyphotic or scoliotic. The face and extremities frequently show suggestions of acromegalic alterations, such as prominent cheek bones, marked superciliary arches, projections of the lower jaw, thickening of the bones of the skull, increase in the size of the sella turcica, and changes in the hands and feet, consisting in a thickening of the end of the bone with growth in length and breadth. Enlargement of the thyroid has been mentioned. Other striking changes are those of the genital glands; there is diminution in sexual activity, lack of potency in man, absence of menstruation and ability to conceive in woman. The internal genital organs are commonly atrophic, and the external organs, such as the penis, vulva, and vagina, are imperfectly developed. The distribution of the hair on the body is abnormal; there is often absence of the pubic and axillary hair and a very small development of the beard in men. The body is frequently more adipose than is normal for the age of the person affected. The disease is more common in men than in women and begins primarily at the age of puberty. Some of the cases ultimately develop a full picture of acromegaly. Alterations in the hypophysis are not infrequent, and may consist in a mere hyperplasia of the glandular substance, or in the formation of adenomata or vascular tumors, while in some cases sarcomata or epitheliomata have been met with. The hypophysis may, however, be both macroscopically and microscopically normal. The mental activity of these giants is frequently very slight, almost always lower than normal. Not all cases of gigantism, however, belong in this class, for some of these people are perfectly normal mentally and show no evidence of pathological change in any of the organs mentioned, that is, the hypophysis, thyroid, and genital glands.

Hypophyseal Adiposity.—A third condition connected with alterations in the hypophysis is the so-called hypophyseal adiposity or dystrophia adiposogenitalis. This disease was first described by Fröhlich in 1901. The persons afflicted show an increasing adiposity, diminished secretion of sweat, atrophic changes in the skin in conjunction with hypoplasia of the male or female genitalia, and alteration in the distribution of the pubic and axillary hair. Connected with these changes are symptoms which may be best described as infantilism. The pathological lesion found in two-thirds of the cases is a tumor of the hypophysis, which in contrast to the condition in acromegaly, originates not in the glandular anterior portion, but rather in cells derived from the hypophyseal duct. Hence a variety of tumors have been found: squamous-cell carcinomata, sarcomata, gliomata, teratomata, and the like. The only vital factor seems to be the injury of the posterior lobe and the infundibular region. Other processes also, such as injury, hydrocephalus, tumors of the base of the brain, can give the same symptoms. Whether the changes are due to a lack of the neurohypophysis or to an interference with the absorption of secretion from the anterior lobe is still doubtful. Pressure on the posterior lobe causes symptoms connected with the genital glands; still stronger pressure causes adiposity. It is to be remembered in this connection that adiposity frequently occurs also in connection with acromegaly. Cushing has called attention to the interesting fact that in hypophyseal adiposity the assimilation capacity of the body for glucose is extraordinarily increased, so that it is almost impossible to produce a glycosuria in these patients by the administration of a large quantity of sugar, even up to 500 grams of glucose. In contrast to this is the glycosuria frequently observed in acromegaly. The occurrence of many of these physical characteristics in connection with the removal of the testicles before the age of puberty, as in eunuchs and persons of certain religious sects in Russia, has led to the suggestion that the condition is primarily an troaphy of the genital glands; but this is shown not to be true by the fact that out of thirty-two cases examined, in only twelve was genital atrophy found. The important part played by the hypophysis has been demonstrated by the experimental work of Biedl and Cushing, who have proved that the removal of the posterior and a portion of the anterior lobe of the hypophysis in young animals produces a picture quite comparable with that seen in man. The animals grow fat, are of low mentality, and show a hyperplasia of the genital organs. A more plausible explanation of the cause of the disease is, therefore, that it is a hypopituitarism produced by interference with the absorption or production of the specific glandular secretion.

Dwarfism.—The study of a certain small group of dwarfs in which the body is well proportioned and the intelligence fairly well developed has led to the conclusion that a diminished function of the anterior portion of the hypophysis may explain the condition. In these individuals the epiphyseal junctions remain cartilaginous; just as in the hypophyseal forms of gigantism the distribution of the hair on the body is infantile in type and the genital organs also remain undeveloped. In some of the cases there has been hemianopsia or optic-nerve atrophy, severe headache, polyuria, and other symptoms which, with enlargement of the sella turcica would lead to the conclusion that a tumor was developing in the site of the hypophysis, accompanied by a diminution in the activity of the anterior lobe.

Diabetes Insipidus.—The fact, which has been frequently observed, that tumors of, or alterations in, the hypophysis frequently result in polyuria, has led to the view that many or even all cases of diabetes insipidus may be traced directly to some lesion of the hypophysis. This assumption has been based partly on the observations originally made by Schaefer that the administration of hypophyseal extract caused diuresis and that mechanical or thermal stimulation of the hypophysis in living animals causes a polyuria, and partly on the fact that polyuria is a somewhat frequent clinical symptom in acromegaly and is occasionally seen in hypophyseal adiposity. It has long been known that certain diseases of the brain, especially intercranial tumors and cerebral syphilis, are frequently met with in cases of diabetes insipidus. The frequent occurrence of this condition with bitemporal hemianopsia has led to the inves igation of the causes of this rare eye disease. The lesions found have usually been syphilitic meningitis, basal tumors, and injuries of the base of the brain. In one observation, where a bullet was found lying in the sella turcica, the patient suffered from a very marked polyuria, passing six or seven liters of urine per day, and also showed some of the other symptoms connected with hypophyseal disease, such as adiposity and lack of sexual capacity. Cushing also has reported a case of hypophyseal tumor with diminished secretion and with hypopituitarism and a normal urinary secretion, which after an operative decompression of the sella and a partial removal of the tumor showed a polydipsia and

polyuria, the patient passing ten to eleven liters of urine a day. This lasted for some three months.

Diabetes insipidus has also been noticed to follow a carcinomatous metastasis into the pars posterior, the normal structure of which was almost entirely destroyed. The pars intermedia and the pars anterior remained intact. In many cases of diabetes insipidus in which no autopsy has been performed, enlargements, deformation, or erosion of the sella have been noticed in *x*-ray pictures. The same extraordinary sugar tolerance which has been noticed in acromegaly is found in diabetes insipidus; even as much as 450 grams of glucose may be given at one time without the appearance of sugar in the urine. Dunn calls attention to the interesting fact that while the sugar was being taken the quantity of urine was markedly diminished. From these facts it has been assumed that diabetes insipidus is due to a hyperfunction of some portion of the hypophysis, possibly the pars intermedia.

FRANCIS CARTER WOOD.

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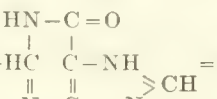
Hypospadias.—See *Penis, Diseases and Injuries of the.*

Hypoxanthine.—  =6-oxy purine.

This substance is a constituent of muscle tissue, bone marrow, and is found in small quantities in the urine and milk. It may also result as a decomposition production of various nucleic acids. It dissolves with difficulty in cold water but more readily in boiling water. Hypoxanthine is readily soluble in dilute alkalies and ammonia and forms insoluble silver salts.

F. P. U.

Hyrtl, Joseph.—Born at Eisenstadt, in the western part of Hungary, December 7, 1811. He studied medicine at Vienna, and, he showed such an extraordinary aptitude for anatomical work, and such a breadth and accuracy of anatomical knowledge, that he was given the appointment of Prosector as early as in 1833. In 1837 he accepted the Chair of Anatomy in the University of Prague; and in 1845 he was called to fill the position of First Professor of Anatomy in the University of Vienna. In 1874, owing to the increasing weakness of his eyes, he was obliged to resign his professorship and to retire to his country-seat at Perchtoldsdorf, near Vienna. He died July 17, 1894.

Pagel speaks of Hyrtl as unquestionably the most celebrated anatomist of his time. "He possessed to a remarkable degree the gift of rendering the driest chapter of his science interesting"; and this statement is equally true of his spoken lectures and of his printed writings. "He had no equal as an academic teacher, and his skill as a writer was marvelous." As sufficient proof of the correctness of this last statement Pagel mentions the fact that between the years 1846 and 1890 Hyrtl's "Lehrbuch der Anatomie des Menschen" passed through twenty editions. Not only did beginners read the book with profit, but even expert anatomists were sure to find in its pages matter from which they could derive instruction.

Hyrtl also possessed a most lovable character. He was the founder of the Home for Orphans at Modling, and to this institution he bequeathed his entire fortune. He provided a number of stipendiary funds, the income from which was to be employed in aiding poor students; and at Perchtoldsdorf, the village in which his country-seat was located, he founded an institution for the care of young children.

In addition to his famous "Lehrbuch" Hyrtl published a number of treatises on anatomical subjects. Of these, however, we shall be able to give the titles of only a few: "Die Corrosionsanatomie und ihre Ergebnisse," Vienna, 1873; "Handbuch der praktischen Zergliederungskunst," Vienna, 1860; "Onomatologia anatomica. Geschichte und Kritik der anatomischen Sprache der Gegenwart," Vienna, 1880; and "Die alten deutschen Kunstworte der Anatomie," Vienna, 1884. A. H. B.

Hysterectomy (from ὑστέρα, the womb, ἐκ, out, and τομή, a cutting) is the removal of the uterus by a cutting operation and may be accomplished through an incision in the abdominal wall (celiohysterectomy) by way of the vagina (kolpohysterectomy), or by a combination of both methods.

Celiohysterectomy includes (*a*) supravaginal amputation and (*b*) the complete removal. Kolpohysterectomy practically always means the complete removal of the organ.

INDICATIONS.—*For the Abdominal Operation.*—Myomata, not removable by myomectomy. Complicated suppurative conditions of the uterine appendages, with matting together of the pelvic structures. Tuberculosis of the uterus and appendages. Cancer. Certain conditions of puerperal sepsis where the uterine wall becomes virtually the wall of a pus cavity.

For the Vaginal Operation.—Bilateral suppurative conditions of the appendages. Prolapse. Cancer. Pregnancy with cancer before the fifth month. Certain septic conditions of the uterus. Certain rare conditions which may require the removal of a small movable uterus.

For the Combined Operation.—Cancer. Failure to secure hemostasis from below.

For the details of these indications the reader is referred to the articles treating of the various conditions.

The operation of hysterectomy is always formidable, and as conditions may arise at any time which tax the resources and nerve of the most skilled and where hesitation or lack of expedient may mean the immediate death of the patient, it should not be undertaken without an adequate practical knowledge both of aseptic surgical technique as applied to abdominal surgery and of the anatomy of the pelvic contents, particularly of the relations of the bladder, ureters, rectum, uterine and ovarine arteries, and large venous trunks.

PREPARATORY AND AFTER-TREATMENT.—The patient is put to bed if possible for twenty-four hours before the operation and encouraged to drink plenty of water. The bowels are to be moved by a gentle laxative and an enema a few hours before operation. The skin of the abdomen is prepared.

After the operation and before the patient is taken off the table she is given a hypodermic of atropine sulphate gr. $\frac{1}{100}$ and a few minutes later a hypodermic of eserine salicylate gr. $\frac{1}{50}$. At the same time she is given an enema of a pint of plain warm water, which is repeated every three or four hours, usually until the bowels move. The eserine is repeated once or twice at six-hour intervals if there is pain or abdominal distention. Morphine is seldom required.

Water is given freely by mouth as the patient may ask for it, but the thirst is much diminished by the enemas. There is usually but little nausea. If vomiting persists the stomach is washed out. The patient is allowed to lie as is most comfortable. The head is kept reasonably high by pillows. If the bowels have not moved by the third or fourth day castor oil or a saline is given.

After an abdominal hysterectomy through the transverse incision of Pfannenstiel the patient is allowed to sit up out of bed for a short time on the fourth or fifth day. With the usual median incision she must be kept in the recumbent position for a longer time and when allowed to sit up must have the abdomen supported by adhesive strapping, so that no strain comes on the incision.

Mortality.—In the hands of a properly skilled operator the mortality after hysterectomy for uncomplicated fibroids should be almost nothing, approximating one per cent. In pelvic inflammatory conditions, not recent, the mortality may rise to two or three per cent. Recent pelvic inflammations give a very large mortality and for this reason operation should not be done; when necessary pus collections in the pelvis can be drained through a posterior culdesac incision and a radical operation done later if needed. The Schuchardt operation for cancer gives a mortality of at least ten per cent. The radical abdominal operation in the hands of expert operators shows an immediate mortality of from twelve to twenty per cent. The Werder cautery operation gives a small primary mortality and probably as great or greater a percentage of freedom from recurrence as the radical abdominal operation.

Technique.—*Abdominal Hysterectomy for Fibroid.*—The patient is put in the Trendelenburg position. The abdomen is opened by (*a*) a median incision beginning half an inch above the pubes and extending upward as far as may be necessary to allow the delivery of the tumor, or (*b*) by the transverse incision of Pfannensteil. In making the incision care must be taken not to injure the bladder, which sometimes is drawn high up. Adhesions are carefully detached, slight ones being wiped free by a bit of gauze and firmer ones divided between two ligatures. Dense adhesions to intestine may require that small areas be detached from the surface of the tumor. The tumor being freed from adhesions is lifted up and out of the abdominal cavity. Large, flat gauze pads with tapes are wrung out of hot sterile salt solution and placed in the abdomen so as to protect and cover the intestines. This packing off of the intestine should be done with care and thoroughly as it adds much to the ease and safety with which the steps of the operation can be carried out.

The finger is then passed under the broad ligament on the more accessible side and guided by it the pedicle needle threaded with No. 2 catgut is passed through an area free from veins so as to include the ovarian artery. This ligature is then tied and occludes the artery and adjacent veins. The ovary is to be left outside the ligature, unless it is so diseased that its removal is desirable. The round ligament is then tied at a little distance from the uterus. A clamp is now placed so as to control the vessels on the uterine side and the tissues between clamp and ligatures divided with the scissors. If the ovarian artery on the other side is easily accessible it is secured in the same way. Inspection of the anterior surface of the uterus will now determine the upper limit of the bladder and the peritoneal incision is continued transversely close above this point. The bladder is then freed from the uterus by being carefully wiped down with a piece of gauze held by fingers or forceps. The uterine artery is now exposed, and a finger passed down by the side of the cervix can feel its pulsation. This artery is to be carefully ligated on one side and then on the other *close* to the side of the cervix, the pedicle needle being passed forward and not outward, so as to avoid the ureter. The cervix is then divided and the uterus and tumor are removed.

When the operator has attained confidence in his technique the procedure is greatly simplified, especially in difficult cases, by first securing the ovarian and round ligament arteries on the more easily accessible side, freeing the bladder, securing the uterine vessels on that side, cutting freely across the cervix until its tissue is nearly divided, catching the lower portion of the cervix with bullet forceps so as to have it under control in case of unexpected hemorrhage. Tearing carefully the last fibers of the cervix the operator will see the uterine artery arching across the torn space. After this has been clamped or ligated, and the remainder of the broad ligament has also been clamped, the tumor is removed. All bleeding points having been secured, the stumps of the broad ligaments are sewed to the cervical stump on either side and the anterior and posterior peritoneal edges brought together so as to cover in all raw surfaces and leave only a seam across the pelvis. The abdomen is then closed.

When it is considered best to remove the entire cervix, the uterine arteries having been secured, the uterus or the cervical stump is drawn away from the vagina and the dissection is carried down by scissors, keeping close to the cervix so as even to leave a slight ring of its tissue in place. When the cervicovaginal junction is reached the scissors are pushed through into the vagina and with this opening as a guide the remaining tissues are easily divided. All bleeding points having been secured a piece of gauze is pushed down into the vagina so that the upper part comes just above the cut vaginal edges, which are to be partly closed together. The peritoneal edges are then closed as in the supravaginal operation. The gauze drain is left in place four days.

Where we have to deal with intraligamentous fibroids, that is where the tumor has developed between the folds of the broad ligament, which is then lifted up over the tumor, the procedure will be greatly simplified by securing the ovarian artery and the round ligament, dividing the peritoneum between the two, continuing the peritoneal incision anteriorly and posteriorly as far as may be, remembering to save every bit of peritoneum possible, pushing the peritoneum off the tumor with gauze and continuing the eneucleation with the gloved hand until the tumor is turned out from its bed, when the operation becomes simple. During this enucleation care must be taken not to injure the ureter or the deep pelvic veins.

Hysterectomy with Wide Removal of the Parametrium for Cancer.—The cervix is first thoroughly curetted to remove any broken down cancer tissue and the vagina is packed with a gauze strip the upper portion of which is wet with tincture of iodine. The strip is left long so as to be easily removed before the final clamping and opening of the vagina.

With the patient in the Trendelenburg position the abdomen is opened by a median incision, any adhesions freed, and the intestines carefully walled off by large gauze pads. Examination is then made for enlarged pelvic glands. If any are found the advisability of proceeding with the operation is doubtful, as palliative measures will usually give more relief with less immediate risk.

The fundus of the uterus is seized with traction forceps. The infundibulopelvic ligament is picked up just outside the ovary, and the broad ligament being put on the stretch, a peritoneal incision is made through its posterior fold beginning near the uterus one centimeter below the ligament of the ovary and extending to the infundibulopelvic ligament which is then ligated and divided. The round ligament is then tied and divided an inch from the uterus. The peritoneal

incision is continued from the infundibulopelvic ligament to the round ligament and across the uterus at the vesicouterine fold. The same procedure is repeated on the other side. The bladder is now gently pushed down from the anterior surface of the cervix with a piece of gauze.

The uterus is drawn to one side and the posterior peritoneal flap drawn toward the median line. The ureter will be found adhering to this posterior flap from which it is not to be detached. The ureter being found it is followed into the parametrium. The uterine artery is tied at a point near its origin. It is sometimes possible where the ureteral sheath is not well developed to pass the finger along the ureter beneath the uterine artery and veins which are then lifted up and tied. Where the ureteral sheath is well developed the ureter must be freed by splitting the sheath and shelling out the ureter. In doing this great care must be taken not to injure the periureteral arterial plexus and so cause necrosis of the ureter. The ureter being cleared the bladder is separated from the vaginal wall. The same process is repeated on the other side.

To free the uterus posteriorly the ureter is pushed away from the posterior peritoneal flap at the point where it enters the parametrium and the flap is severed to the uterosacral ligament. Both uterosacral ligaments are ligated and divided, the peritoneal incision being carried across at a point which leads into the loose cellular tissue between the vagina and the rectum. The rectum is then freed from the posterior vaginal wall by blunt dissection with the finger or gauze.

The uterus can now be lifted up considerably and the parametria become more accessible. The ureter is now drawn gently toward the side of the pelvis so that the plexus of veins from the uterus, bladder, and vagina may be secured. This is often difficult, yet a wide excision of these tissues is of the greatest importance. It is useful to remember that these veins all converge toward a point at the pelvic brim near the ureter.

The parametric tissues having been all tied off, the uterus is now free except for the vaginal tube. After having been carefully inspected to see that the bladder, rectum, and ureters are free, the vagina is clamped with two right-angled forceps, one above the other, and cut off between the clamps with the cautery, having first been thoroughly dried from below. The clamp on the vagina is then removed and a piece of gauze passed down to wipe away any necrotic particles.

All bleeding points being secured the vesicouterine peritoneal fold is sutured to the anterior vaginal edge and the rectouterine fold to the posterior edge. All raw areas should be covered in with peritoneum. If drainage is used care must be taken that it does not come in contact with the ureters.

If the condition of the patient is good toward the close of the operation, the easily accessible internal and external iliac lymph nodes should be removed, but in this country the extensive removal of the glands is seldom done.

The most important postoperative complications, aside from the sequelæ common to all severe abdominal operations, are vesical and ureteral with an associated renal infection. The bladder should not be allowed to become distended. The patient should void her urine if possible but if there is retention or residual urine the catheter should be used followed immediately by irrigation. Ureteral fistula may occur from accidental injury during operation or from injury to the vascular periureteral plexus causing necrosis. A fistula frequently closes spontaneously though it may later require removal of the kidney or ureterovesical implantation.

Vaginal Hysterectomy with Hemostasis by Ligature.—Patient is placed in the lithotomy position. The cervix is dilated, the endometrium curetted and disinfected with iodine. The perineum is retracted and the cervix drawn down by a strong vulsellum forceps. An incision is made through the mucosa entirely around the cervix and the tissues pushed back everywhere to a distance of three-fourths of an inch or more by a finger covered with gauze, the finger keeping close to the uterus. The tissues are freed anteriorly to the vesicouterine-peritoneal fold, the bladder being well separated from the uterus, posteriorly to the rectouterine peritoneal fold and laterally to the broad ligaments. The uterus can now be drawn down much lower. The posterior culdesac is now opened close to the uterus and the opening enlarged by tearing with two fingers. A large gauze pad with tape is introduced into the Douglas' pouch to protect the pelvic viscera and absorb blood. The anterior peritoneal fold is cut through and the opening enlarged broadly by tearing with the fingers. Any adhesions about the appendages are then freed by the fingers. The bases of the broad ligaments with the uterine arteries are carefully tied by a series of catgut ligatures (some prefer silk or linen with the ends left long) and divided. The further application of ligatures may be facilitated by drawing the fundus so the uterus through the anterior opening by mean of volsell a forceps.

It is often necessary to use separate ligatures for the appendages and especial care must be taken in securing the ovarian artery. When the uterus is large or the operation difficult the uterus may be split in midline and each half drawn down, ligated and removed separately.

All bleeding points being secured, the anterior and posterior peritoneal edges should be approximated with catgut, the stumps of the broad ligament being sutured together below. In complicated pus cases the opening left by the removal of the uterus is utilized for drainage.

Vaginal Hysterectomy with Hemostasis by Clamps.—The procedure is the same as with ligatures until the broad ligaments are cleared. Then a strong, straight pressure forceps with jaws about two inches long is clamped over the base of the broad ligament which is then severed close to the uterus. The same is done on the other side. The fundus with the appendages is then anteverted into the vagina and forceps applied over the tops of the broad ligaments, the forceps ends slightly overlapping the ends of the forceps applied from below. The handles of the forceps are then brought together twisting the broad ligament on itself, bringing it well into the vagina, and ensuring that each forceps holds its artery in the firmest part of its bite.

In case of difficulty the uterus should be bisected before any clamps are applied and each half brought down and clamped separately. When possible the peritoneal edges should be brought together above the clamps. Gauze packing in strips is then carefully introduced between the clamps and so as to protect everywhere the vaginal mucosa. The clamps should be firmly tied to guard against accidental unlocking. The handles of the clamps are to be wrapped with gauze. They are to be removed after forty-eight hours by carefully unlocking them, slightly separating the blades, and loosening them by slight rotation on their long axis. The dressings are not to be changed for another forty-eight hours and then with great gentleness and care so that no intestine may come down in case the peritoneal surfaces have not united.

The advantages of forceps over ligatures are: Their use naturally shortens the operation; drainage is efficient; all tissues caught in the forceps slough, an advantage when it is desirable to remove as much tissue as is possible as in cancer; with proper forceps properly applied hemostasis is secure. The forceps is often preferable in serious pus cases with the patient in bad condition and where the ligaments are apt to be thickened and difficult to reach.

The disadvantages of forceps are: The very painful and more or less complicated convalescence, and the presence of sloughing tissue in the vagina.

Paravaginal Hysterectomy, or Schuchardt's operation, has been little used in this country, though enthusiastically advocated by Gellhorn of St. Louis who describes it as follows:

With the forefinger and thumb of the left hand the operator seizes the posterior portion of the left labium, while an assistant seizes the parts in the middle line and puts them on the stretch. The operator then makes the incision between the two sets of fingers dividing the vaginal wall nearly to the cervix and downward and backward to the middle of the coccygeal region. The incision thus splits the whole vaginal tube, the left labium, the paravaginal and pararectal tissues, the levator ani and coccygeal muscles, the cellular tissue of the ischiorectal fossa, as well as the skin of the perineum and of the lateral anal region down to the sacrum. The wound in the pararectal tissue is situated to the left only so far that the rectum and sphincter ani are not injured. It lies only about a finger's breadth from the middle line. The incision on the left side is more convenient for the right-handed operator. A bilateral incision is only necessary when a portion of cancerous rectum with a portion of cancerous vaginal wall must be removed.

The effect of the paravaginal incision is surprising. In place of a vaginal tube we have before us a shallow excavation not deeper than one inch, and at the bottom of this the parametria are seen in full extent and within easy reach.

The copious venous bleeding from the incision being controlled, a circular incision through the vaginal mucosa is made at right angles to the paravaginal cut. The vagina is dissected upward and the cuff thus formed sewed over the cervix. The sutures are left long and serve as guides. The bladder is now separated from the anterior uterine wall and Douglas' space is opened behind. The left forefinger is passed behind one and then the other parametrium to drag it within easy reach and the parametrium and broad ligament on each side are ligated as far outward as possible with strong catgut.

The closure of the wound begins with the suture of the corresponding edges of the peritoneum with catgut, the cut ends of the broad ligaments being drawn into the vagina and fixed there by sutures. The vaginal wound is then closed.

The advantages of paravaginal hysterectomy are said to be the following: The patient, who is usually in poor condition, is subjected to considerably less shock than by the abdominal operation. There is less danger of infection than after abdominal section. The intestines not having been handled, postoperative complications are less apt to be expected. The method affords easy access to the cervix and parametria. The freeing of the ureters undoubtedly affords the greatest technical difficulties. With the necessary experience, however, this part of the operation can readily be effected, especially if we employ preliminary catheterization of the ureters. Operability by the paravaginal method is identical with that of the radical abdominal operation. There must be clinically free parametria to premise the possibility of operation.

Hysterectomy by Cautery.—Byrne taught us the importance of the cautery in the removal of cancerous disease, holding that the best safeguard against recurrence was thorough cauterization of wound surfaces and edges from which cancerous materia had been removed. Byrne's method was essentially a high amputation of the cervix with the cautery with thorough cauterization of the stump and gave results which have seldom been equalled by more radical modern methods.

Werder, following the lead of Bryne, has developed a method which gives remarkable freedom from recurrence with a very small primary mortality. His technique is as follows:

The cervix is curetted with a heavy sharp spoon curette until all necrotic tissues are removed and the bleeding surfaces are cauterized until all bleeding is controlled. The cervix is then firmly held by volsella forceps and an incision is made entirely around the cervix at some distance from the affected area by means of the cautery knife, keeping it at a dull heat and never turning on the current until the knife is placed against the tissues to be burned. In this manner no oozing will take place and the parts will remain perfectly dry. While making traction upon the cervix the bladder is separated from the uterus, a retractor carefully drawing the bladder away from the hot knife. Douglas' pouch is opened in the same manner and the lateral vaginal attachments are burned through. All surfaces not thoroughly charred are gone over carefully with a dome-shaped cautery. The vagina is lightly packed with gauze.

The abdomen is opened by a median incision above the symphysis, the uterus seized by volsellum forceps and the intestines carefully packed back with gauze pads. The bladder peritoneum is now dissected off from side to side with the cautery and the bladder pushed down exposing the vaginal gauze. A broad Downes electrothermic clamp, well oiled to prevent sticking, is now applied to the infundibulopelvic ligament and round ligament and the tissues in the clamp thoroughly cooked until a thin, white, horny ribbon is obtained. The clamp is then removed and the ribbon cut through at its inner margin and, if there is no bleeding, is dropped. The other side is treated in the same way. The parametrium is seized with the clamp on the least affected side and burned through, great care being taken to avoid the bladder and ureter. The ribbon thus formed is cut through and the remaining portion of the broad ligament and the uterosacral ligament are treated in the same manner and dropped. The same thing is done on the other side. If the technique has been good the clamped surfaces will be perfectly dry. The bladder peritoneum is now sewed to the posterior peritoneal edge and all stumps covered with peritoneum. The abdomen is then closed.

Where the uterus can be brought well down and the vagina is large the whole operation can be done from below. The operation then differs little from the ordinary clamp method of vaginal hysterectomy except that all incisions are made with the cautery knife. The broad ligaments being cleared, two ordinary clamps are applied on either side and the uterus and appendages removed. After packing off the pelvic cavity carefully with gauze pads the upper clamp on the infundibulopelvic ligament is seized, put on the stretch, and a broad Downes electrothermic clamp applied externally to it and the tissues cooked until a good ribbon is obtained. The Downes clamp is then removed, the ribbon cut through near its inner edge and if no bleeding occurs, dropped. The other clamps are then treated in the same way until all the uterine attachments have been cooked.

The last step of the operation is another cauterization of the stumps. For this purpose the parametrial pedicles are gently grasped with forceps and after the surrounding tissues are carefully protected with pads they are completely seared and charred with the dome cautery. Finally after thorough cleansing of the pelvic cavity and vagina the anterior and posterior peritoneal edges are united by a few catgut sutures thus closing the pelvic cavity but leaving space for an iodoform gauze drain along the charred stumps of the parametria. The drain is removed after about four days. During convalescence the patients have little pain and usually make an ideal recovery.

Brooks H. Wells.

Hysteria.—Under this concept, medical science attempts to group a series of phenomena the complexity of which has defied complete analysis. At the present time it is highly improbable that any valid definition can be formulated which will include all of the facts which may be grouped within this concept. For many years medical science has been satisfied with an analysis of the acquired meaning of the word "hysteria," and for the most part has neglected the study of the behavior of the thing—the human being showing hysterical manifestations. It is doubtful whether one can draw a hard and fast line between what may be called isolated hysterical manifestations and the disease itself, for after all the concept of hysteria is of purely pragmatic value. It is therefore immaterial whether one attempts to distinguish between what is called hysterical and what is called hysteria, so long as an energic concept is utilized to cut into the facts. Such a concept is here offered in the form of a statement that the essential feature in that which is called hysteria shall be psychical conversion into somatic phenomena. Thus any somatic symptom, no matter in what part of the body it may be found, which is the result of symbolic conversion from purely mental causes, may be designated hysterical, and the disease hysteria itself may be designated as a collection of such conversion phenomena.

Seen from this point of view, hysteria is one of the most common of all diseases. It is of very wide incidence and makes up, one might almost say, the major portion of the practice of most physicians.

Seen from the psychological side, this capacity for physical conversion of psychical phenomena is an index of the growing up of the race. Hysterical, therefore, to this attitude of mind, means infantile. Such infantilism may be present as a result of feeblemindedness in certain of its groups, or may be an index of faulty psychical modes of handling the many complex reactions in daily life. The hysterical mechanisms furthermore have a teleological value. They are not only infantile, but highly instinctive and often distinctly conservative. Such a definition also prompts one to say that the term hysterical may be applied not only to the manifestations of energy within the individual, but that society as a group of individuals also shows in many of its institutions precisely analogous phenomena which may also be termed hysterical, and which are indications themselves of the infantile attitude of the masses. Le Bon, in his masterly essay on "The Psychology of the Crowd" has shown how widespread these reactions may become, and how the institutions of specialized society tend to show hysterical traits the moment a mass reaction takes the place of an individual one. The pragmatic test of the value of democracy therefore is offered along such a line of interpretation. When the reaction of the mass becomes hysterical it shows its inferiority to what might be called aristocratic or individualistic adaptation.

History.—From the earliest times, there are records among all people of the widespread character of this mechanism. Some of the historical landmarks of most interest are given in the works of Pommes, Brachet, Gilles de la Tourette, Richer, and Binswanger. Cesbron gave a critical history of hysteria in a Paris thesis in 1909, while the general historical aspects have been gathered by Jelliffe in the seventh volume of Osler's "Modern Medicine." It is interesting to trace the gradual growth of interpretation concepts which have sought to explain the manifest phenomena called by various names at various periods by various physicians of the times. Certain features have remained fairly constant. These, however, have been among the most striking of the motor phenomena of hysteria, and it is not at all surprising that even at the present time the vastly more important and widespread, though more subtle, manifestations of hysteria should be overlooked.

The earliest hypotheses concerned themselves with more or less gross anatomical features, the earliest formulation of which gave the name to the disorder. It is said that Democritus first assumed that the wandering uterus brought about the reaction, and it is highly probable that the teachings of the Hippocratic school were faint echoes of previous modes of interpretation. The grosser beliefs in a wandering uterus were naturally more or less demolished by the careful anatomical studies of Galen who, showing that the uterus was a fixed structure and not capable of wandering, substituted a bit of humoral pathology only slightly deviating from the original standpoint. No longer did the uterus itself wander, but the humors developing within the uterus, menstrual or what not, being unable to find a satisfactory outlet became the cause of the phenomena. With the gradual growth of medical science the belief in gross humors, such as those just outlined, fell away. They only became more tenuous, however, and throughout the Middle Ages—even down to the first part of the nineteenth century one heard of vapors, of gases, etc., as causative of hysteria. The symbol became more ethereal. Logic displaced the grosser superstitions, but has not entirely eradicated superstitious modes of interpretation, and thus we have the belief—still persisting among animistic thinkers—in autointoxications and similar attenuated kinds of humoralism as causes for hysterical phenomena.

The transformation of the causative symbol from the grossly organic, wandering through humoralism to the thinly attenuated chemical poisoning, becomes complete when the energic concept passes from the physical to the psychical, and we finally have substituted a type of psychical determinism as productive of the phenomena. This is more in line with the general attitude of the times which views the central nervous system as a transformer of external energy rather than an originator of the same, and the present-day energic or dynamic concepts offer much more plausible types of explanation to cut into the facts than have heretofore been presented. Such explanations will undoubtedly also have their day and the formula of "*conversion of psychical energy into symbolic physical manifestations*" will probably seem crude in the medicine of the future. Still, at the present time, the formula explains the manifestations better than the previous formulæ, offers a more definite viewpoint from which to attack the problem of therapy, and some notes concerning its historical development may not be out of place.

It is with Charcot, one may say, that the psychological doctrines had their distinct formulation. Not that there were not lacking physicians before Charcot who clearly saw the mental origin of the hysterical manifestations, but it is to him and his school, particularly to Janet and to Freud, that the definition of the psychopathology of hysteria owes its base. In the term "dissociation" introduced more particularly by Janet, one had the first promising concept. By it was meant the possibility of a process whereby psychical energy could modify physical function and yet remain as it were unknown to the performer. The doctrine of the "unconscious" was a necessary corollary, and the psychology of the unconscious has now become one of the most important features of modern interpretation not only of hysteria but of all mental phenomena.

Symptoms.—Aptly termed the great mimic, one finds countless possibilities in the hysterical phenomena. The unconscious, as White has well termed it, "is our historical past," and any part of it may thrust itself upon some organ of the body to impair, or bring down its functions to more primitive levels. The great classics of Brachet, Richer, Briquet, Pitres, Binswanger, and others offer rich catalogues of these various disguises under which the unconscious seeks

to find expression. The instinctive and intellectual forces of civilization and of culture seeking to repress the primitive forces of life's energy in their urge for expression of individual and racial immortality are compelled to make compromises because of human frailties. Such make-shifts may be determined by the presence of inferiorities of the organic structures, as Adler maintains, but such deficiencies, physical or chemical, are only determiners of the localization and character of the symptoms, the psychical needs of the human being in its relations to the broader social values of the human herd are the true dynamic factors in bringing out the compromise reactions which we term the symptoms. Unconscious egotism provides the push, the repressions which demarcate lower from higher social values, distort and fashion the outlets, which finally emerge as the variegated mimicries of the hysterical mechanism of conversion.

It is no wonder that the non-comprehending have always been stupid in sight of what they term the inconsistencies since the hysterical individual is so frequently judged from the attitude of conscious logic, whereas really to comprehend we must see the illogical consistency of the unconscious. Herein lies the bewildering confusion of the symbolism of the unconscious. Jean Paul has said that "language is a dictionary of faded metaphors." The reading of hysterical phenomena requires an insight into the lost significance of these metaphors as expressed symbolically in the symptoms.

Hence every hysterical symbol has its psychical meaning hidden behind the disguise of a disturbed bodily function. A partial list of some of the symptoms, so called, will be here attempted. Space does not permit any interpretation of their symbolic significance since every patient's unconscious, being his own historical past, makes the disguise a purely individual one. Thus, blindness may express a wish not to see something definite in the environment; it may signify the desire to be blind to an internal obligation; it may express the lack of desire to see a moral delinquincy; or it may be an unconscious portrayal of a blindness which would mean innocence. Each symptom has its own special significance for the individual, although accumulating psychoanalytic experience is showing that broad general trends are capable of being mapped out.

Before proceeding to outline these trends a word as to the character of the observations available for study is perhaps in order. Hysteria, looked upon as a thing, reached its apotheosis with Charcot's work. Following this, the vast amount of material on hand created the necessity for close scrutiny and, mingled with real fragments, careful analysis brought to light much that was worthless and an astonishing number of diagnostic errors, some the result of mental laziness, some the offspring of credulity. With the advent of the finer modes of investigation now in use, the possibility of falling into these errors has almost reached a vanishing point, and many patients who might be thrown into the class of hystericals receive the attention which their condition requires. Paralyses, hemiplegias, monoplegias, paraplegias, etc., heretofore provided the most fertile field for error, but the newer signs of organic involvement of the nervous system provide an unfailing means for the recognition of nervous disorder, and indolence has no excuse for diagnosing as hysteria the organic disorders which may lie at the back of these symptoms.

Simulation, although not very frequently met with, is a feature of what has been called the hysterical mentality, and is a constant factor which must be guarded against, at the same time that the possibility of its occurrence should not be allowed to undervalue the statements of patients who may be deserving or discourage their careful study.

Hysteria is a general tendency to reactive expressions. The difficulty met with in describing it is an evidence of the instability of the concept, its width, and the fluency of its outlines. The possibility of the hysterical reaction is inherent in every person, and its appearance depends on either the stimulus or the change in resistance. The satirical saying that "every man has his price" has its analogue in the truth that every individual has his hysterical Jack-in-the-box. Whether it will go off or not depends on the strength of the spring and the force put on the lid. When one finds a malady apparently due to thousands of causes, one comes to the conclusion that none of them has anything to do with, or else that each may play a minimal rôle, and so it would seem with the hysterical personality. Whereas one man bears the loss of a million dollars with patient endurance and quiet dignity, another has a hysterical dream state after losing a purse. It may take the loss of a husband or a child to unloose the hysterical mechanism of one, while the death of a pet parrot is sufficient to keep some women in bed for a month with an attack of hysterical paraplegia.

The aphorisms of a people reflect the aspirations of their affective lives. In the one to whom the proverb "still waters run deep" applies, it will take a severe shock to unhinge the mechanism of affective control. So it is with the many small difficulties of life, what is by one digested and forgotten will in another ever rise like the garlic of a bygone dinner, and produce its disturbance in the affective sphere.

The greatest barrier in the way to the study of the hysteria problem has been the difficulty of reaching the phenomena of the most significance, and which perhaps offer the clearest modes of explanation. The various theories which we have discussed represent the master keys which, for the authors at least, seem to have unlocked the doors of the hysterical crypt.

So far as present clinical experience goes, the hysterical domain can be entered only by the same roads that one must travel to enter the fields of internal medicine, the field of psychiatry, the field of epilepsy. Excitement, depression, and dementia no longer constitute the high roads through the kingdom of psychiatry. Epilepsy no longer remains a unity, explicable through any single cause, and so it is with hysteria. It is a vast hierarchy, almost a social organism in the psychical life of the individual, and clinically must be so regarded.

The hysterical character is chameleon like in its variations, appearing in all classes, in the intellectual as well as the weak-minded, and, badly expressed, shows many resemblances to the childish type of mind. Aside from minor variations, it manifests itself chiefly by emotional instability, by the ease with which it is influenced, in negativism and impulsiveness, a tendency to make sensations, a remarkable egotism, desire to confabulate, to fabricate, and to simulate. Seen from the standpoint of the psychiatrist, these mental attributes stand in the foreground; the neurological manifestations are dependent upon them, and modern analyses of hysteria lay stress upon the psychical anomalies.

Excessive lability of the emotional life is most striking. There is constant change of mood and activity. Gaiety is changed in a moment into depression, and prolonged periods of happiness are followed by equally moody depressions. They are readily hurt, and bursts of tears follow the slightest reproof, or it may be that they relieve themselves by passionate scorn, or violent anger. They are happy and busy, or discontented and idle, sympathetic at one moment and antipathetic the next. The mood can rarely be counted upon; smiles are succeeded by frowns and friends and relatives are at a loss to explain the change, or are constantly on their guard to avert the consequences. As Sydenham said "all is caprice. They love without measure those whom they will soon hate without reason." Many of these patients develop into the spoiled darlings of the household.

Male hystericals shows a greater tendency to prolonged depression, which fact probably influenced the earlier writers, especially Sydenham, in terming these patients hypochondriacs.

Suggestibility is one of the most essential traits in the genesis of this mental state, and volumes have been written on the subject. Many claim it to be the master key of the whole problem, and the classical description by Babinski who would set apart a special group in the hysterical medley under the term pithiatism, is founded upon this feature alone. True pithiatism (hysteria) for Babinski consists in those conditions which can be brought about by suggestion and cured by persuasion.

This peculiarity is to be looked for in a particular type of idea associations of which Jung and Riklin have made a special study in recent years. In the foreground of the hysterical reaction type—for one can speak of general types only—are to be found more or less independent active idea complexes of great emotional value whose development is enormously greater than in normal individuals. The association test reactions are permeated with disturbances due to these complexes, many of which are only slightly repressed by apparently harmless reactions.

Up to this time no formula adequate to define suggestion and suggestibility has been enunciated. It is true that psychiatry has freed itself from the notions of witchcraft, demoniacal possession, and such like, but essentially the same ideas remain in the minds of the populace, although disguised under such names as telepathy, mind influence, absent treatment, and so on. It is almost a common place to remark that independent thought is an impossibility for by far the larger proportion of the populace; they must, therefore, be led by the few, and adopt the phrases, formulæ, and ideas of the few. This simply means that practically all people are more or less easily influenced or led by the suggestions of others. What is common to so many is found greatly exaggerated in a few—these are for the most part the hystericals, but it is only to certain types of action that they are suggestible. Janet speaks of them as showing the type that leads to dissociation as a result of the narrowing of the field of consciousness.

Hysterical Exhibitionism.—A desire to be constantly in the limelight, whether for the purpose of attracting attention or of inviting pity, is another feature. Romantic accusations, sensational confabulations, self-mutilations, and refined theatrical attempts at suicide—hysterical dream state suicidal accidents are not meant here—these have their motive power in this desire to be the observed of all observers. Lies, slandering, disfigurations, and stealing are not too much to bring this about. In the present state of journalistic enterprise in certain countries, opportunities are not lacking to gratify these ambitions. The thoughtful see in such journalism the source of much hysteria of the proletariat.

The exaggerated ego of the hysteric has received much comment from earliest times. The attention is fastened pathologically on the ego, and the constant search for bodily sensations on which to hang complaints is pursued with definite, though concealed, pleasure and refined meditation. The slightest sensation is seized upon and magnified. Somatic pains, for instance, are not created by the neurosis, but are merely utilized, aggravated, exaggerated, and retained by it. Careful examination—psychoanalysis as well as physical—will in almost every case find a nucleus of organic foundation. Freud shrewdly observes that it is always the common, the most widespread pains of humanity that seem to be most frequently called upon to play a part in hysteria. The ills of others, however, receive small sympathy, and we frequently see envy and jealousy arise if others' pains are considered of moment in comparison. To be sick and the center of the stage becomes a life work, a theatrical apprenticeship, which with masterly tutelage by many physicians usually produces a finished artist in the end. Such were the famous Charcot cases, which the neurologists of Paris, the pupils of Charcot, now admit were the products of a too fervid culture. Martyrdom, the negativistic phase, is a self-evident corollary.

Confabulation should receive special attention. From its origin in day dreaming and the delights of fantasy, poetic fiction gradually passes through the stage of unconscious warping of truth to deliberate falsification. The will to believe becomes pathological, and a facile imagination soon fills the gaps in actual observation, even if it does not supply amnesia itself.

Motor Disturbances.—Attacks.—The ancient representations by artists of major hysterical attacks show no variation from modern photographic studies of similar cases. These convulsive attacks have always attracted great attention and contributed the most striking phenomena. The capacity for this type of conduct has existed from the earliest days and is one of the most remarkable and persistent of the features of hysteria. That fundamental human mechanisms are being played upon by the most primitive agents is shown by the transmission down through the ages of the same positions, the same attitudes, cries, and contortions.

Striking major hysteria attacks have varied so little in their manifestations that little can be added to the older descriptions. They are so little the rule that some physicians never see them, and German students have been found to maintain their absence. The Charcot school was richest in observations of these phenomena. Germany to-day provides three times as many studies on hysteria as France does. The matter of absolute frequency is a question that cannot be resolved, since there are so many factors as to make generalization impossible. The religious manifestations of one people are considered major hysterical outbursts by another. Epidemics come and go, local agitations and general excitements create the proper milieu for major hysterical manifestations; the possibilities seem always there in all peoples; the environmental factors may alone be lacking, and contemporary movements, which offer plenty of material for the study of major hysterical manifestations, may always be found.

In questions of this kind, statistics are absolutely unreliable. For instance, Briquet whose clientele was practically all women, places the percentage of major hysterical attacks as high as 72. Pitres in his summary gives 81 per cent. of 69 women, and 22 per cent. of 31 men as subject to major attacks. This was in the Charcot times and under the influence of active imitative and suggestive factors. Binswanger found that 25 per cent. of 52 male patients, and 54 per cent. of 50 female patients suffered from convulsive attacks with well-defined hysterical symptoms. Gotz' figures give 3 per cent. in 75 patients. Voss, whose statements as to race should be taken with caution, found a percentage of 65 in 22 men, and 57 in 101 women.

Although, as we have seen, the general type of major attack has shown great persistence, it has many modifications, of which the most severe are those accompanied by contortions. Some authors have endeavored to create for the major hysterical attack a march similar to that of the epileptic convulsion, but this does not agree with clinical findings. The lack of uniformity is universal. If purely general lines are sought the hysterical attack may be described as showing three stages—a prodromal, one of muscular convulsions, poststadium.

The prodromal stage, sometimes incorrectly spoken of as an aura, is of very frequent occurrence. It usually appears as a state of mental unrest with signs of restlessness, irritability, crossness, or depression. Often both mental and motor retardation are present, and a feeling of general distress, or a sense of tension which may result in fits of anger, crying, or general

moodiness. With the fuller development of the attack some of these phenomena increase in intensity, the patient may show great anxiety, and feelings of localized tension appear, such as clutchings at the throat, palpitations, or a feeling that the skin might burst, or the stomach explode. The patients hear sounds, things dance before their eyes, they become dizzy, and then begin to show convulsive movements. In some patients the attack develops very slowly and with apparent quiet. The indications of severe muscular spasms, such as sudden respiratory spasms, passing of gas, yawning, etc., may appear only at the end of a long period of quietude, perhaps a whole day spent in bed, with the head in the pillow. Sometimes the attack may take days to culminate, and again a few minutes may be sufficient for its full development. As a rule, early attacks take a longer time to develop, while the later ones reach their full strength within a few minutes, and may be precipitated by the slightest cause. Many attacks which show signs of being major never show the discharge phenomena, and do not get past the period of motor outbreak.

The convulsive stage is a stage of extreme muscular tension of a tonic character. The classic picture is that of a slow extension movement, the head thrown back, the arms extended, fingers extended or in tight fist, legs straight and stiff, and toes extended. The face, rarely mask like, gives more often the impression of one in a day dream of phantasy, and the general tonus of the whole musculature is in marked contrast to that of an epileptic convulsion. The attitude assumed by the body is often quite characteristic, and among devotees the crucifix position is very common. Variation in point of time is also seen in the development of the position. Very frequently there is a progression from the head and shoulders, then to the waist, and lastly to the lower extremities of a sort of snake-like extension that is like a gigantic, overdrawn stretch. Local groups of muscles may show isolated extension positions. Some attacks may consist solely of these slow, sinuous extension movements, followed by slow relaxations and again slow extensions, to which some of the ancient authorities, as well as many moderns, have attributed a strong erotic coloring.

No marked neurological changes appear upon examination, which may be made during a period of quiet or in the postparoxysmal stupor. The pupils, which are usually widely dilated, as a rule react to light, although both slow reactions and loss of light reaction are known, and Redlich reports a good deal of variability. As analgesia is usually present, sensory tests are obviously impossible. Organic paralysis is not present in hysteria, and the deep reflexes are not markedly altered, but marked diminution of the skin and mucous reflexes may be found. Only in rare instances is there loss of urinary and defecatory control. The Babinski reflex is usually absent.

Postconvulsive Period, Dream States.—Here are classed those patients of whom one reads so much as the "living dead," and "buried alive." According to Pitres, about one-half, or according to Binswanger and Voss a smaller proportion of the major hysterical cases pass into this state of lethargy which may persist for days or even weeks. The patients lie immobile, with closed eyes; breathing is almost inappreciable, and they may go for days without attending to the wants of nature. Careful examination shows that the urine leaks away little by little in some patients; passing the feces in bed is also reported. Some patients may be actively delirious, carrying on a conversation, sometimes coherent and again incoherent, with imaginary personages about them. They appear to be in a semi-dream, spoken aloud, and abounding in phantasy. Some of these dream states show all the characteristics of a katatonic dementia precox, while others have the appearance of mildly confused manic depressives. Ziehen has given a very useful description of this whole group in his text-books.

The subgroups into which these states may be divided are varied and many. The attack often serves as the point of departure for many of the interparoxysmal phenomena. The patients wake up lost, as it were, to their surroundings. They may have wandered from home in a state of somnambulism and have little memory, or very hazy or isolated bits of memory concerning their actions. Patient analysis may bridge over the gaps and reconstruct a history of the mental wanderings, but the investigator will do well to guard against the possibility of aiding the memory of the patient by suggestion.

Charcot and his followers produced these major hysterical attacks experimentally by pressing upon the ovarian region, the mammary region, etc., to which the name "hysterogenic zones" was applied. This was pure training; Charcot had his patients so trained that pressure on an ovary would cause an attack, pressure on the mamma would bring it to a close, while pressure on the two areas simultaneously caused no reaction. Science calls this sort of thing suggestion; much of it was deception though not of a conscious type. It was simply unbounded, uncritical faith on the part of physician and patient alike. In spite of the literature written on the subject, hysterogenic zones do not exist, if one restricts the meaning to the direct influence of definite peripheral irritations as capable of inducing hysterical attacks without the influence of psychical, suggestive factors on the part of the investigator. Again it has been denied that major hysterical attacks could be consciously induced by the mere willing, but there is evidence that negatives this view.

Rhythmic Movements, Tremors.—We are indebted to the work of the Charcot school for a description of the many varieties of tremor to be found in patients subject to hysterical reactions whether complete or fragmentary. A threefold classification is given, namely: (1) trepidation, (2) vibratory, (3) intentional. Simple tremor, with the hands at rest, is of frequent occurrence. Static tremor, when the fingers are strongly extended and spread apart is less often seen, while intention tremor is comparatively rare. Mixed forms are the rule, and the polymorphic character of the tremor is diagnostic. The tremor is usually rhythmic, but irregular, ataxic, chorea-like tremors are sometimes seen. These tremors may appear in various parts of the body, and the eyelids, tongue, mouth, fingers, shoulders, legs, etc., may be affected. Horizontal axis tremors of the head are possible of confusion with the early paralysis agitans tremor. When the muscles of the mouth or tongue are involved characteristic stuttering, or irregular pseudoparalytic speech disturbances are produced.

Intention tremor, closely resembling the tremor of multiple sclerosis, is met with in hysterical affections. It chiefly appears in traumatic, and particularly in medicolegal cases. It must not be forgotten, however, that true multiple sclerosis tremor is not infrequently diagnosed as hysterical and care should be taken in differentiation. Coincidence of localization with changes in sensibility is especially significant. The combination of absent tremor in the supported hanging hand with intention tremor is seldom met with in hysteria.

Coordinated impulsive movements, such as hysterical crying and laughing, are common hysterical explosions particularly among young women approaching the age of puberty. The histories of most hysterics show the presence of these emotional expressions in the early stages; and they are generally to be found in the middle grades of the hysterical temperament. Binswanger offers certain diagnostic and prognostic signs concerning these attacks and the severity of the hysterical psychoneurosis in general. In one class one observes them as a single expression after emotional shock. In such cases they may be looked upon as the expression of a pathologically emotional

irritability, the explosion being out of all proportion to either the duration or intensity of the affect shock. They are usually a sign of definitely hereditary constitutional inferiority on a basis of the same type of disturbance in the ascendants. Binswanger regards their symptomatic importance as being less grave here than when found in the group in which acquired or congenital neurasthenia lays the foundation. In the first group they are perhaps the only disease feature in the personality, while in the second they may be indicative of general instability, and are more frequently accompanied by the development of a more complete hysterical symptomatology.

Other types of coordinated impulsive movement attacks have been described, some of them of a very uniform character, such as grimacing, hopping, etc., but modern investigation has shown a tendency to throw the majority of these over into the dementia precox reactions. Had patients, subject to these reactions, been kept for a sufficient length of time under observation in the early days of investigation, the development of dementia precox would have been recognized, and although hysteria might have been poorer in symptomatology, the whole concept would have gained in clarity.

Arrhythmic Movements, Choreiform.—Although hysterical tremors are usually rhythmical, irregular, incoordinated, unwilled, the picture is sometimes complicated, and the difficulty of diagnosis increased by the presence of large movements of a choreic type, the difficulty being further enhanced by the fact that combinations of chorea with hysteria have been observed. Imitative choreas, attaining the proportion of epidemics, are of historical record. The matter has been further complicated by Charcot's assumption of essential relationship between chorea and hysteria, which relationship, however, is purely superficial. In all choreic affections the important factors of infection or excessive growth with mental or physical fatigue should not be overlooked. To call a chorea hysterical in the absence of rheumatic fever is nonsense.

Akinetic Motor Phenomena, Paralyses.—Weakness or loss of muscular power is among the most frequently seen of the marked manifestations. The variations in both extent and grade of akinesis are very great. Although references to monoplegia and hemiplegia are found as early as the writings of Greek and Latin authors, it is only in recent times that the essential differences between somatic and psychic paralyses have been defined, and it is only of late years that clinical neurology has been put in possession of definite criteria by which to test the psychic nature of these pareses and paralyses. The larger number of hysterics have some grade of muscular weakness or myasthenia which may remain undeveloped, or under the influence of suggestion may be converted into paralysis with marvellous rapidity. Clinically these myasthenias are hysteroneurasthenic in character. They are of pure psychogenic character, and are generally due to the influence of psychic processes, and the depressing effect upon motor innervations of a sense of anxiety, dread, fear, displeasure, pain, or helplessness. They should be differentiated from neurasthenic myasthenias. Care should be taken to separate them from somatic myasthenias, especially from those of some obscure spinal-cord lesions, early multiple sclerosis, small circumscribed myelitis, slowly developing tumors, low-grade pressure neuritis, or certain intoxications with which they may be easily confused. Of the most outspoken paralyses, hemiplegia, and monoplegia are the most striking; mixed types, triplegias, quadriplegias, etc., are also to be met with.

Hemiplegia, according to Ziehen, may be met with in fifty per cent. of the total paralyses. It may be incomplete—diplegic, arm and leg without cranial involvement, the commoner form, or in rare cases with cranial nerve additions, or mixed hemiplegic with the opposite arm or leg. The quadriplegias are still more rare and alternate hemiplegias are curiosities. The appearance of hemiplegia almost invariably accompanies an affect shock, or may develop after a major hysterical attack. The onset, which is often accompanied by a sense of weakness or giddiness, is nearly always acute, paralysis being at once manifest. Only in rare cases does it advance slowly. In occasional instances its development is accompanied by pain, nausea, and vomiting.

Clinically considered, the signs of somatic disease are absent in these paralyses. The absence of pathologically increased tendon reflexes, clonus, increased tonus, Babinski's phenomenon, Oppenheim's reflex, of modification of Schaffer's paradoxical reflexes, Van Gehuchten's inguinal cutaneous reflex, the femoral reflexes of Remak, of Grasset's, Peaucier's, Hoover's, and Babinski's hip-thigh associated movements, etc., all show the non-involvement of the cerebral pyramidal neurones. That the peripheral neuron is not involved is proved by the presence of knee-jerks and of the Achilles jerk, the absence of atrophy (unless produced by the development of contractures after long disuse), and the absence of nerve tenderness (unless psychogenic) together with unaltered electrical excitability, hypotonus, trophic skin disturbances, etc.

While these signs are the usual diagnostic landmarks which define the distinction between hysterical (psychical) and organic (somatic) cases, there is need for great caution in laying too much or too little stress on variations which undoubtedly exist. This need is strongly emphasized in recent literature on the subject. Thus, while it is clearly realized that the reflexes should be normal, according to Babinski always, the knee-jerks are very active as a rule. Binswanger Sternberg, Westphal, and Voss report ankle clonus, which by some is called pseudoclonus. Oppenheim describes foot tremor, and Déjerine has demonstrated that patellar and foot clonus may be present in exceptional cases. Recently a good deal of discussion has been raised as to the possibility of the presence of inferior cutaneous reflexes, and particularly of Babinski's phenomenon, heretofore considered absolutely diagnostic of involvement of the pyramidal tracts. Roth, Van Gehuchten, and others have reported the occasional presence of a Babinski toe phenomenon in hysteria. Judgment on this point must be deferred in view of the amplification of the modern conceptions of the many factors which may cause this phenomenon.

The motor cranial nerves are rarely involved in hysterical palsy. Cases of ophthalmoplegia should be critically examined with the possibility of hysterical contractures in view. Differentiation between paresis and a spasm is extremely difficult and though Borel and Parinaud have reported some cases of oculomotor and abducens paralysis, they are extremely doubtful. Hysterical ptosis is not infrequent.

Facial palsy is a sign of special interest. The supraorbital branches are not often implicated, although it is possible that all three branches may be involved. Clinically special attention should be paid to the risk of seeing a palsy on one side to the neglect of a real hysterical contracture on the other.

Glossolabial involvement has been noted, and considerable variation exists regarding the position of the tongue and palate. A mixture of spasm and paresis seems to be present in most of the cases. In the hysterical aphonias the movements of the palate have been observed to be less ample. Inferior alternate paralyses need to be carefully enquired into, although some cases have been reported.

Paraplegia.—Statistics relative to the incidence of this affection are not available. Paraplegia superior is of rare occurrence, while paraplegia of the lower extremities is seen with greater frequency. This is found either as a typical paralysis of the lower ex-

tremities with complete or partial ability to move the limbs, or as an abasia (astasia abasia), in which there is conservation of power to move the limbs while in a horizontal position, but inability to use them in the vertical position. Hysterical paraplegias may be analogous to either the flaccid or spasmodic type of paraplegia, and transitional types are the rule. Contractures are met with with comparative frequency. The most frequent exciting cause, especially in young girls, sometimes in children, is trauma, railway accidents being a very fruitful source. The onset is as a rule brusque, though the development may be gradual, and Voss suggests the excessive tire in the lower limbs of anemic young girls as a contributory cause. The distribution is apt to be extensive, although restrictive movements may be preserved. The patellar reflex is apt to be exaggerated in both types, but the absence of the signs noted under the heading of hemiplegia point to the psychogenic nature of the disturbance. Although some authors have noted involuntary defecation and urination, the functions of the bladder and rectum usually remain normal. Care should be taken to guard against mistakes in diagnosis, since the indefinite symptoms produced by small spinal-cord hemorrhages may be easily mistaken for hysteria.

Astasia-abasia, first described by Blocq in 1888, is an irregular, incomplete type of paraplegic disturbance, from which it differs by reason of the absence of paraplegia or ataxia of the limbs in the sitting or reclining position but only when the patient tries to stand or walk. Even complex motor acts may be performed, dancing, etc. Among others, Oppenheim and Binswanger regard it as a syndrome met with in other conditions than hysteria. It is undoubtedly of psychogenic origin, and should be considered as a hysterical combination with, rather than an integral portion of the other psychoneuroses.

Pseudotabes is an allied disturbance of which Pitres has given a full analysis. Analgesia, pains, disturbance of the eyes, incoordinated movements are all symptoms which make differential diagnosis a matter of difficulty, but modern methods of investigation should make impossible such an error as that of Charcot, who diagnosed as tabes a condition which was afterward cured at Lourdes. It may be noted that hysterical symptoms are sometimes seen in true hysterics.

Monoplegias of hysterical origin are very frequent. They are of irregular distribution, mention having been made of paralyses of the third, fourth, or sixth nerves, of the facial and muscles of the pharynx and larynx. Hysterical ptosis, single or double, spastic or flaccid internal or external rectus, etc., show that the involvement of even a single muscle of a nerve innervation group may be involved. Brachial monoplegias are perhaps the most frequent, leg monoplegias are rarer.

Disturbances of Touch.—These consist of anesthesia, hypesthesia, and hyperesthesia. Total general anesthesia is probably a condition of extreme rarity, and Pitres' statement that it is present in twenty per cent. of the cases is a Charcot school extravagance. To the six cases which, out of the many reported, Binswanger regarded as authentic, Voss has added six from the literature and two from his own observation. Some of these patients showed "dream" state conditions, and it is difficult to arrive at a correct estimate of their value. Anesthesia may be general, unilateral, isolated in spots or patches, or may involve symmetrical regional areas. Hypesthesia, *i.e.* incomplete anesthesia, is of more frequent occurrence than anesthesia. Hemi-anesthesias or hemi-hypesthesias are not infrequent, and are perplexing in variety and complexity. At times there is even variation in intensity in the portion of the body affected. Involvement of the left side is most often seen; crossed anesthesias (*e.g.* anesthesia of the face on one side and of the body on the other) are known. Involvement above the waist on one side, and below it on the other have been reported. Patch-like anesthesia or hypesthesia, the breast and forearm being especially involved, are also seen. These patch-like anesthesias show a variability comparable to if not greater than the well-known geometrical distribution. This latter which is known as the stocking and glove type rarely corresponds to any anatomical nerve area. The border line is usually indefinite, not alone during the examination, but also on comparison with other examinations, and the patients are unaware, as a rule, of the anesthesia which rarely causes inconvenience. At times, however, they complain of pain (anesthesia dolorosa) or pricking, or compare the sensation to the crawling of ants, or the feeling of a limb that has gone to sleep.

Pain Sensibility.—Hyperalgesia and analgesia are both of frequent occurrence, hyperalgesia especially being, as is well known, a very common hysterical symptom. So true is this that in some one or other of its forms it is to be found in almost every hysterical history. Hysterical points or zones of tenderness on deep pressure, usually unilateral, are seen with great frequency, the more common being the iliacal (so-called ovarian), also present in men, inguinal, just above Poupart's ligament (hysterical appendicitis), epigastric, mammary, jugular, supraorbital, and infraorbital, and the vertebral points. The most classical points are usually those upon pressure of which physiological stimuli are more readily set up in the normal individual. Pressure upon other zones, or even the same point may bring about the cessation of an attack. Pressure on these points may also determine localized pains, paralyses, contractures, ataxias, etc., and on the other hand may be used to cause them to disappear. The location of these points and their relation to the hysterogenic zones, which have already been spoken of, has been much discussed, but after all they have no real relation to the disease. Suggestion is the important element. In these areas, pressure with suggestion seems to have more influence than in other zones, but other suggestive influences may produce exactly the same phenomena.

Complete analgesia may occasionally be found in hysterical dream ecstatic states. Hypalgesia, or general diminution of pain sensibility, is perhaps as common an occurrence as general hypesthesia, and is met with under the same conditions. Hemi-analgesia and hemi-hypalgesia march with hemi-anesthesia and hemi-hypesthesia, and crossed varieties have been described. The usual pupillary response to painful stimuli is obtained in many of these cases, thus the integrity of the reflex mechanism is assured even if there may be repression of the psychical pain associations.

Deep sensibility may be affected, though very rarely, and when this happens the affection is not followed by ataxia or any other of the usual pathological phenomena. Deep anesthesias are much less common than hyperalgesias or analgesias. Dissociations with lost tactile and lost deep sensibility, or *vice versa*, are among the hysterical anomalies recorded which require more corroboration and more exact observation.

Temperature Sense.—Variations in temperature sense are not unknown, but complete studies of tests made in accordance with Head's teachings regarding epicritic and protopathic sensibility are not yet available. Cold nearly always has a striking effect upon the hysteric, especially when applied *en masse* as by a shower bath or cold pack. A few cases of dissociation of temperature and tactile sense, and also of dissociation of warm and cold have been recorded but they are not very convincing. Loss of ability to distinguish heat and cold seems to follow the modification of tactile anesthesia. Patients with loss of temperature sense are rarely known to burn themselves, but burning in hysterical thermanesthesia has been recorded.

Mucous Membranes.—Disturbances of sensibility

of the mucous membranes, analogous to those of the skin, are known. According to Thaon, as large a proportion as one-sixth of all hysterica have anesthesia of the epiglottis without resulting respiration pneumonia. Record has also been made of anesthesias of the mucous membrane of the mouth, nose, ear-drum, urethra, and rectum.

Spontaneous pains of variable character are to be met with in probably at least eighty per cent. of all hysterics. They may be said to form themselves into five general groups, namely topalgias, neuralgias, arthralgias, enteralgias, cardialgias.

1. Topalgias, circumscribed painful areas with no anatomical relation of any known nerve distribution. A careful study of Head's zones may prove that many of these topalgesias are symptomatic of visceral disease. The modern tendency is to recognize more and more the strength of Head's position, that a great mass of symptoms have been regarded as hysterical which are really peripheral reflex disturbances due to visceral disorder and disease. On the other hand, mastoid topalgias and appendical topalgias have mistakenly been made the reason for unnecessary surgical interference.

2. Neuralgias.—These should have careful consideration as many neuralgias which have been deemed to be hysterical have proved to be symptomatic of grave disturbance. Therefore, even when apparently not agreeing with the anatomical distribution of a nerve trunk they should be diagnosed as hysterical only after careful elimination of organic features. A cervical rib may account for a persistent brachial neuralgia, or the presence of sugar in the urine may reveal the diabetic origin of another.

3. Arthralgias or pains in the joints should never be diagnosed as hysterical without a radiographic examination, even when they are accompanied by hypesthesia, hyperesthesia, or even typically hysterical gait or contractures. However, the existence of true hysterical arthralgias seems probable, since some cases have received definite and rapid relief from psychotherapy.

4. Enteralgia.—The existence of enteralgia, or visceral pains of psychical origin, has received uncontrovertible proof from the evidence contained in the literature. Babinski and Strümpell, class hysterical ileus, with pain and vomiting, in the "simulation" group, but Bergman, Voss, and Naunyn are among the believers in its hysterical origin. A. Dubois is the author of a monograph on hysterical appendicitis. Vomiting is a well-known hysterical symptom, and E. H. Müller notes the possibility of the psychic origin of hyperemesis gravidarum. Reversed peristalsis seems to Muhsam to be of psychogenic origin also.

5. Cardialgia as an hysterical symptom is of very frequent occurrence. It may take the form of palpitation, sense of oppression, irregular pains, quick pulse, dropped beats, or even angina pectoris. This, its most severe form, is however rarely seen. Hysterical bradycardia has also been described (Triboulet).

Déjerine has written at length on a group of symptoms which may be classed as the false pathies. They are often the result of injudicious medical suggestion, and are frequently met with as complications of hysteria. Some have been classed with the hysterical symptomatology, some with hysteroneurasthenia, some in Janet's psychasthenia, but they should all be kept in a group apart. Such are false gastropathies, mental anorexias, false enteropathies, false genitopathies, etc.

Sight.—While, as we have noted before, total hysterical blindness is not unknown, it is very infrequently met with. One-sided blindness, however, is frequent. It may be differentiated by the fact that the eye grounds remain normal, and the pupillary reactions unmodified. Its acute onset immediately after psychic shock, and lid reflex to unexpected light are also diagnostic signs of value. Voss has reported a case with diminution of consensual light reaction in a unilateral amaurosis, but careful observation on this point remains to be made. Diminution of vision, usually involving the left eye, is a common subjective complaint. Since the publication of Féré's work, restriction of the visual fields has been a commonly accepted manifestation. These restrictions have been described as concentric and bilateral, and are claimed for a large majority of the cases, according to Voss a fourth and to other authorities as high as a third. Increased fatigue, and inability to concentrate the attention are the usually rationalized etiological factors. Blindness is usually a wish-fulfilling mechanism.* Among rarer anomalies recorded, central scotomata, sector and ring-shaped defects may be mentioned.

Hearing.—Voss has described bilateral hysterical deafness in combination with hysterical paraplegia. Nevertheless, hysterical deafness is rare, although cases have been recorded by Binswanger, and others. There may be modification of bone conduction, but as a rule there is no alteration in the quality of the voice, such as is typical when organic affections of the ear are present. Wieber, however, has some observations which are contrary to this rule.

Smell.—The status of variations of smell in hysteria is not very definite although a large amount of work on the subject has been done. Lichtwitz found complete and half-sided anosmias; Babinski has been unable to find any anomalies without palpable suggestion, while Voss gives the proportion in his cases as thirty per cent., which is also the general proportion of all cases found in the Berlin clinic. Gilles de la Tourette is inclined to look upon such disturbances as being of diagnostic value. Ziehen makes a systematic investigation of smell in every case in his clinic and finds great irregularities in smell in the non-hysteric. Voss finds that the left side is most often involved.

Taste.—Alteration of taste is infrequent, although many writers have reported variations for sweet, bitter, sour. Ageusia often accompanies facial anesthesia. Hyperageusia is especially pronounced. Hemilateral ageusia and hyperageusia are described.

Hysterical Fever.—This is due to a disturbance of the heat regulatory centers. Manahiloff, who made a critical study of the subject, published as a Montpellier thesis in 1903, has come to the conclusion that hysteria, without the aid of other disturbing factors, may cause rise in temperature. In this conclusion he is supported by Kausch, Oppenheim, and Voss. There are, however, others who deny such a possibility.

Skin Changes.—The presence of purely hysterical lesions of the skin is still a much mooted question. Babinski claims that they are all of artificial production. Kreibach and Matzenauer have observed in hystericals a very definite increase in motor irritability, with the slightest skin irritation resulting in gangrenous necrotic ulceration. Beitmann, Ziehen, Bayet, and Thomer find great sensitivity of the skin in its reaction to external irritants. Beitman in particular has reported a case of gangrene in an hysteric as the result of the application of a weak lysol solution. There is no doubt that many cases of skin lesion are the result of deceit, but there is also no doubt of the psychogenic origin of many others, while a still greater number are the outcome of hysteria superimposed on the foundation of a slight trophic or vasomotor disturbance. As these hysterical skin affections develop very quickly, it is not idle to suppose that the regenerative process may work with equal rapidity, an hypothesis which may be an explanation of the indubitably authentic cures of ulcerous processes reported from various miracle working shrines. Bullous dermatitis is not infrequently observed as an hysterical phenomenon, while among the rarer types of so-called hysterical skin disorders are reckoned acne, psoriasis,

* Ames: Blindness as a Wish Fulfillment. Psychoanalytic Review, vol. i., No. 1.

erythema, urticaria, dermographia, ecchymoses, chromidrosis, vicarious bleedings, etc. Cassirer has written an excellent review of the literature on this whole subject.

Psychoses.—Hysteria "au large" is itself primarily a psychosis, but within its borders are to be found a series of phenomena, at times closely related to the somatic disturbances, to which the term may be more definitely applied. Of these the so-called hysterical dream state (Dämmerzustand) is perhaps the most important. It is closely analogous to the dreamy delirium so well known in the case of epileptics and of some alcoholics. These dream states may follow a major hysterical attack or may appear as it were like a bolt from the blue. They may be of only a few minutes' duration, or may last for weeks; may scarcely interfere with the patient's orientation or conduct, or may take the form of deep, continuous slumber, or stupor, in which the patient lies with closed eyes, sunken head, and relaxed muscles. Here may be found the "living dead" of flaring newspaper headlines. Dream states may end in a convulsive seizure. Between the extreme types there are many variations, such as somnambulism and fugue-like flights. In the former, clouding of consciousness is not very deep; in the latter, patients have been known to take long voyages, being unable, on coming to themselves to account for their actions. They may even commit criminal acts, and important and difficult medicolegal problems arise. No matter what form the dream state may take, it is usually followed by partial or even, in rare cases, complete amnesia.

Another form of mental disorder of hysterical origin is Ganzer's "Vorbeireden." Here the conduct of the patients is exceedingly foolish, approaching that of young children. They are short and snappy in their answers, burst into uncontrollable laughter, imitate the cries of wild animals, and are very difficult to manage. When interrogated, they seem careless of their replies, giving indirect or inverse answers, half answers, at times contradictory answers. Superficially it seems as though these answers were deliberate attempts at falsification or simulation, but the great similarity in type is sufficient to allow of the recognition of the Ganser symptom. This symptom may also be met with in epileptic dream states and in alcoholism, and is still more common in dementia precox.

Secretory Disturbances.—Hysterical emotional states wield a great influence over the organs of secretion. Lack of perspiration, which may be unilateral, and local hyperidrosis have been described, although as a rule the sweat glands are not involved. Pilocarpine has been found useful in correcting these unilateral anomalies. Affection of the salivary secretion usually takes the form of diminution, though Matthieu and Roux have described a remarkable case, complicated by excessive vomiting, in which the secretion amounted to two-thirds of a liter daily. There may be increased nasal secretion with sneezing attacks, increased bronchial secretion with an accompaniment or coughing, or an excessive swallowing of laryngeal or pharyngeal mucus, increase in the flow of tears or absolute dryness. In making a diagnosis of hysteria on the strength of these disturbances, all possibility of tabes, multiple sclerosis, or syringomyelia should be eliminated as cases have been known where these serious somatic disorders have been overlooked.

Urinary secretion is also greatly influenced, and much variation is found. Polyuria is met with with great frequency, particularly in major attacks, and Matthieu has reported a case in which from thirty to forty liters a day were excreted. Incontinence is not frequent, and when present usually accompanies a paroxysmal or interparoxysmal phenomenon. Care should be taken in dream states to prevent overdistention of the bladder. Anuria, a common symptom in Charcot's days, is not now often observed. Here again Babinski claims simulation, but cases of relative anuria, accompanying hyperidrosis or excessive stools, are occasionally seen.

The researches of Pavlov and his school have given definite experimental proof of the modifications produced in the internal secretions by the mental state, which had been known empirically since the days of Hippocrates. Cannon has done the same service for intestinal secretions. The secretions may be either diminished or increased, and hysterical diarrhea is well known. The glands of internal secretion are under vegetative control and are profoundly influenced by the psyche.

Reflexes.—Modifications of the reflexes are so many that they may be categorically enumerated. There is frequent diminution of the corneal, conjunctival, and palpebral reflexes. The corneal reflex is rarely absent, and the secretion of tears is not modified, as a rule, even in the presence of diminished corneal and palpebral reflexes. Little is known of the jaw jerk. Occasional irregular distribution of the sneezing reflex is found, but neither this modification nor the loss of either pharyngeal or faucial reflexes is of much diagnostic value. Irregularities of both of these latter are often found in non-hysterical individuals, especially in those who have had much throat treatment.

The triceps and radial periosteal reflexes are usually increased, but may not be obtainable where contractures are present. They may be lost. Their diagnostic value, however, is very small. Marked irregularity would point to organic lesions. The abdominal, epigastric, and cremasteric reflexes are subject to considerable normal variation, but when unequal, organic affection should be looked for; mistakes occur over the contraction of the abdominal muscles. Modification of the cremasteric reflex is unusual, even when there is anesthesia of the skin. Vaginismus is a rare hysterical reflex, and the anal reflex may be absent, though occasionally it shows hyperesthetic sensibility. Anal hypesthesia is of common occurrence, especially among women. What relation this has to Freud's anal erotics is not yet known.

As a rule, there is symmetrical increase in the knee-jerk. Its loss as an hysterical sign, though denied by Babinski, is undoubtedly seen, although this is a rare finding, and may later permit of other interpretations, a statement which may also be permitted for the Achilles jerk. This latter should, however, be tested in the kneeling position when its absence is indicative of organic lesion. Nonne and Willroth found a periodic loss of the tendon reflexes. Attention has already been directed to the Babinski sign.

Metabolic Disturbances.—Gilles de la Tourette found no marked deviation from normal metabolism during the interparoxysmal period. During the attacks, however, a modification of the usual relationship of calcium and magnesium to the phosphates of potassium and sodium may take place, *i.e.* there may be an inversion of the formula of the phosphates. Binswanger's studies provide no new material on this point.

Great loss of flesh is frequently seen, an extreme example being the "human skeleton" reported from Lourdes as cured. This emaciation is usually the result of not eating, though some patients lose weight in spite of fairly normal feeding. A few cases of hysterical adiposis have been recorded, but their exact significance is doubtful.

Bleeding.—Hysterical phthisis, gastric and kidney hemorrhages are no longer, as a rule, ascribed to hysteria. There remain, however, a number of bona fide hysterical phenomena, such as bleeding from the skin, mucous membranes, or viscera, sometimes called vicarious menstruation, etc. The bleeding may be scanty or profuse, although in the latter case the general health does not seem to be affected. The

locations of the bleedings have been legion, some of them are artefacts, often unconsciously produced, but others are psychical conversion phenomena.

Diagnosis. In his "Psychopathology of Everyday Life," Freud has related his confusion in overlooking an abdominal lymphosarcoma in a fourteen-year-old girl who also had exquisite hysterical manifestations. Similar experiences are universal. No one is immune from making such mistakes. There is no disorder of the human body which has not been mimicked by hysteria, and the diagnosis of hysteria has been incorrectly attached to practically every known somatic disorder. A complete differential diagnosis therefore would range over the entire field of medicine and surgery.

On the one hand, it may be stated that hysteria should be a diagnosis arrived at only after the most rigid exclusion. This is a practical viewpoint which emphasizes the rationality of the attitude of mind of the organicist. On the other hand, the almost absolutely psychical character of certain symptom combinations is sufficient to stamp a process as hysterical with great positiveness when seen from the angle of the psychiatrist.

Balancing the two attitudes however, experience seems to point to the former as being the one less likely to lead to disaster, even though it may mean a great waste of time. The chief reason for the supremacy of this orthodoxy is, however, the lack of training in mental phenomena in medicine. So long as the study of bowels is considered of greater value than that of brains, just so long will the physician be compelled to go through all the somatic gateways in order to find that psychical disturbances are not to be found in that direction. Fortunately the checks and counterchecks are accumulating which enable the moderately serious student to avoid the more gross diagnostic pitfalls.

Most of the diagnostic mistakes wherein organic is termed hysterical are due to sheer carelessness in examination. The rush of social conditions prevents one from giving enough time to the patient. Economically, at times, the physician cannot afford the time. The patient therefore who pays grudgingly for time suffers abundantly. Penny wise and pound foolish is a maxim of great pertinence in that branch of medicine wherein psychical disturbances are considered. The patient who would willingly pay thousands for the removal of an innocuous fibroid on the "scare" of its possible degeneration into a "cancer," will grudge paying a penny to straighten out mental attitudes which ultimately develop suicide, murder, asylum internment, divorce, scandal, dismembered families, or irremediable heartache. The physical fact looms large; to the psychical fact man is blind and deaf. This is as apparently true of the physician as of the man in the street. The great stumbling block is that the physician gets to believe too much in the authority of words. Their apparent definiteness is apt to blind him to the fact that they are only provisional explanations for things. Man's intellect manufactures them to aid him to interpret the behavior of things. If this function of words be kept clearly in mind, the problems of diagnosis in hysteria become comparatively easy. Symptoms of somatic origin are seen to be distinguishable from the same symptoms when of psychical origin. Thus pain, seen not just as a word pain, but as the behavior of some organ or organs to definite dynamic factors capable of producing it, becomes the object not of a text-book search, but of actual observation and interpretation, either as a physicochemical, a sensorimotor, or a psychical adjustment of organ or function. Possibly all three sets of mechanisms are involved as may be well exemplified in certain syndromes. Exophthalmic goiter, for instance, where psychical conflicts induce metabolic (endocrinous) disturbances, with resultant sensorimotor readjustments such as sweating, palpitation, etc.

These general remarks are intended to emphasize the fact that man is not a physicochemical mechanism alone, nor a sensorimotor reacting device, nor yet only a human being in a human society seeking psychical adjustment to the needs of self-protection and race propagation. He is all three. His psychical needs rank the highest, else he would have remained at the lower levels, an earth worm, a Venus fly trap perchance.

Hence the most vital questions with which the physician should occupy himself, if the problem of hysteria arises, are those of the human interests of the patient.

The patient is not psychically sick because his digestion is disturbed, or his sleep interfered with, or his liver working badly, or his intestines absorbing non-existing, hypothetical poisons, but because his psychical needs are upsetting his digestion, his sleep, his liver metabolism, his intestinal functions.

The diagnosis of hysteria will for some time no doubt be reached by the method of exclusion. The cart will be put before the horse to resolve a variety of situations which because "it does not work" have to be abandoned for a better hypothesis. The psychical conversion hypothesis moreover does not apply to all hysterics. In fact, most patients with predominant hysterical mechanisms show other symptoms. Thus practically one has a mixed psychoneurosis in each and every case; some with pronounced neurasthenic symptoms; others with compulsive thinking, phobias, obsessions, tics, habit movements, others even with psychotic admixtures, hallucinations at times, traces of delusional interpretations, etc. Just what any particular medley shall be called is a secondary matter after all. Giving arbitrary labels to kaleidoscopic pictures is illusory. When one is considering the individual patient one does not care to give a name to a series of processes, one should understand the why and the whither. A child may understand the name given to a *choo-choo* car, but this knowledge does not enable him to manage one; so to name a series of processes going on in a sick body, hysteria, neurasthenia, compulsion neurosis, psychasthenia, etc., is of no particular service to the patient. It is another matter when technical hypotheses are sorted and compared in a society of those using these logical tools. Then diagnostic word symbols have a value. This side of the problem of diagnosis, however, will not be entered upon.

Hysteria from the mental aspect represents a mode of escape by the patient from reality. This mode is symbolically expressed through the symptoms. These are unconsciously developed in accordance with character traits which are fundamental to the individual. These fundamental character traits are in course of formulation from earliest infancy, and their chief features are apparent in the very young. Heredity plays a part—how much is uncertain—in creating or imparting somatic structures to carry on the work with reality. Environment—father, mother, family, society—affords educative features, cultural restraints and outlets for the psychical striving—the libido of the individual. This libido, working with better or worse organic structures, in accordance with well or badly managed repressions, gives the character type of the ego, which, striving for antisocial, asocial, or social ends determines the value of the individual, *i.e.* his sickness or his health. Inasmuch as the conversion or defense mechanisms are subversive of social value they are called diseased, and also, when of a special type, hysteria.

In the *neurasthenic* syndrome of older authors, many conversion mechanisms were included. But a preferable way of looking at neurasthenia is to regard it in the light of a very definite somatic disorder. It is a fatigue due to definite organic factors. Such are seen after acute or chronic exhausting disease, after

poisoning, after great grief or shock, or continuous worry. Here the patient is unable to meet reality, not by a sidetracking of his libido, by means of a mismanaged repression through conversion. They really have little energy free to convert because of the exhaustion or toxic process. One is not speaking here of vague toxemias, as yet too tenuous even for hypothetical purposes. The neurasthenic is not trying to dodge reality. It is thrust upon him and he cannot handle it. He may in addition run away and utilize certain mechanisms of defense or conversion, may superinduce hysterical phenomena—oftentimes a stupid environment forces him to use such a reconstructive avenue of escape, but neurasthenia is here considered as a fatigue without conversion phenomena. In other words, a diagnosis of neurasthenia must include the somatic cause. It is not a psychogenic disorder. It is somatic. Rest and food will necessarily get it well in the absence of malignancy, or incurable somatic disease, nephritis, etc. If the hypothesis "nerve fatigue" does not work, the diagnosis is incorrect. Truth is truth only "when it works."

Another somatic syndrome very frequently called hysteria is *multiple sclerosis*. Here smaller or larger plaques in the nervous system interfere with proper neuron activity. Fatigue is an early sign which, in the absence of other more definite indications of nerve disorder, is too frequently termed functional. Occurring, as multiple sclerosis does, in comparatively young individuals, the mistake is all the more natural. If it be kept in mind that multiple sclerosis usually begins with fatigue, is frequently monosymptomatic for a long time, and usually shows the so-called classical triad—increased reflexes (clonus), nystagmus, and scanning speech—only after a long time, or in acute developing cases after several months, one should not confuse the two disorders. Intention tremor as a hysterical monosymptomatic sign is very rare and must have some good psychogenic explanation (accident litigation, etc.) whereas in multiple sclerosis it is frequent. A careful neurological examination should settle all questions.

Disease of the midbrain frequently leads to a faulty diagnosis of hysteria, especially when the sensory pathways are initially involved. Here anesthesia and peculiar irregular movements are carelessly termed hysterical. Careful examination by Head's methods will show the nature of the illness. Syphilitic disorder of the midbrain structures is not infrequent and a faulty diagnosis of hysteria may cause the loss of much valuable time in therapy.

Similarly early cases of *paralysis agitans* with pronounced emotional disturbance, which very frequently precede the motor changes (tremor, etc.) are called hysteria, especially where the psychogenic factors in the disorder are not properly valued.

The Epilepsies.—Although they possess a superficial likeness, and the casual observer may mistake a major convulsive attack for an epileptic seizure, and *vice versa*, there is no real similarity between them. The same disease process, however, may be the exciting cause for either condition, and both may be present in the same person. The reduction in resistance due to the growth of a cerebral tumor may be the cause of hysterical outbreaks in a patient in whom the pressure of the tumor induces epileptic convulsive seizures.

The signs for differential diagnosis may be categorically enumerated. Thus, the ordinary signs of epilepsy are loss of consciousness, complete amnesia, involuntary urination, more rarely involuntary loss of feces, pupillary immobility (not invariable), clonus or Babinski at end of attack (not invariable), exhaustion and sleep. In convulsive hysteria attacks we have nearly complete loss of consciousness, partial amnesia which association experiments may clear up, little or no injury to the tongue or body, absence, as a rule, of involuntary discharge of urine or feces, absence of ankle clonus and Babinski, no pupillary disturbances, absence of fatigue, or even of desire to sleep.

Meningitis Cerebrospinalis Acuta.—The advent of lumbar puncture, and the utilization of bacteriological and cytological examinations have satisfactorily eliminated most of these cases.

Organic Brain Disease.—It is a well known fact that the signs of the early stages of organic brain disease have been mistaken for hysteria. It is therefore of the utmost importance to eliminate such grave matters as trauma with microscopic lesions, gummata, syphilitic meningitis, septic encephalitis, hemorrhagic meningitis, brain tumors, cerebrospinal carcinosis, for all of these have been known to be accompanied by typical hysterical symptoms.

The real difficulties, however, lie not so much in the consideration of these somatic disorders, whose nature ultimately shows itself, but rather in the more distinct mental disturbances which are grouped under the broad terms psychopathic personalities, dementia precox, manic depressive psychoses, etc. Here there are great diagnostic difficulties, since here one is dealing with psychogenic factors and with broad generalizations which in themselves are purely provisional hypotheses—and not over certain ones at that.

Psychoses.—As might be expected, hysterical symptoms are found in many of the non-hysterical psychoses. This is especially so in the manic depressive group, and the early stages of dementia precox and in the presenile and senile depressions, and is occasionally true of general paresis. Care should be taken in differentiating the dream states of epilepsy, and alcoholism, manic stupor, catatonia, and traumatic dream states.

Dementia Precox.—Jung's studies on the psychology of dementia precox and those of Bleuler on negativism emphasize the enormous difficulty in separating this symptom grouping, in its early stages, from hysteria. Jung has explained in part the reasons for the difficulty, while Jelliffe believes that the symptoms though identical are indicative of different stages in the break up of the personality. He argues that just as one reaches the same point and sees the same view in going up or coming down a mountain so the dissociations of personality in the loose *synthesis* which we call hysteria may show the same, or almost the same, pictures as we find in the dissociation of a *disintegrating* personality which we name dementia precox. Often the history is the only aid in deciding between a catatonic stupor and an hysterical dream state. Sudden onset after a psychic shock points to hysteria, while a longer slower course implies catatonia. Both conditions share in common foolish conduct, negativisms, catalepsy, amnesia, grimaces, analgesias, etc. Refusal to take food, and long standing negativisms are indicative of catatonia, unilateral pressure points, and disturbances of sensibility of hysteria, while hystericals, even in dream states, are much less likely than catatonics to be uncleanly. Stupor preceded by change of character, such as emotional stupidity or disinterestedness, by hypochondriacal ideas, ideas of influence, and menstrual disturbances, should make one suspect catatonia very definitely.

The emotional apathy of the dementia precox patient parallels the indifference of the hysterical. Both are the result of covered up, hidden or repressed complexes which are much more difficult to dig out in the case of the precox patient because of his mental disintegration. In the hysterical the mood is broken up by an explosion—violent crying, muscular contortions, or some analogous outburst. Both disorders show a diseased, exaggerated phase of the normal disposition to repress the unpleasant and bury it deep down. In the hysterical, following psychoanalytic investigations, we find conversions and transmutations:

in the dementia precox patient we see peculiar transpositions and blocking which prevent adequate reactions to reality. The Œdipus complex appears baldly in the open in dementia precox and in the paranoid form the tendency to father identifications become very marked phases of the picture.

If too much importance be not attached to them, the terms "hysterical character" and "dementia precox-character" are very useful concepts. All types of temperament may be found among hystericals, yet it is characteristic of these personalities that a powerful emotional complex is present which is incompatible with the ego complex. Such emotional complexes, which are also present in dementia precox patients, show themselves in studied and pretentious behavior, artificial gaits, philosophical enthusiasms, religious originalities, etc. Delusions of social elevation in dementia precox manifest themselves in exaggerated manners, studied speech, bombastic expressions, affected eloquence and high sounding phrases. Hysteria and dementia precox show themselves alike in quasi-religious schemes.

Treatment.—Prophylaxis and individuality of treatment should be the slogans in dealing with hysteria. Complete knowledge of the history of each individual case is essential. That gained, tact and ability to seize and use every means at hand should enable one to accomplish much and gain permanent results.

He who would wield the weapon of prophylaxis must have a knowledge of the influences which are most productive of the hysterical character and must recognize the wisdom of changing or modifying its environment wherever possible.

Syphilis, tuberculosis, and alcoholism in the parents prepare the best soil for the production of hysteria. Therefore, it would seem the part of wisdom to avoid the marriage of blood relations where nervous affections are present, and the marriage of syphilitics and the tuberculous should be scrutinized. One cannot over-emphasize the dangers to the offspring of such marriages.

Prevention of accidents during childbirth, the hygiene of the pregnant mother, the hygiene of the nursling and child are all of the very gravest importance even when looked at from the point of view of hysteria alone. "Baby worship" and unwise overstimulation of the infant mind are two great sources of evil. So is the constant discussion of diet. This should never be carried on before young children. The diet of the growing child is important, but it should never be thrust upon his consciousness, or as a matter of fact upon the consciousness of the adult. Alcohol in every form, tea, and coffee should be eliminated from the child's diet which should consist of simple well-cooked food, containing plenty of carbohydrates, and abundance of fresh vegetables. Monotony should be avoided so as to prevent the growth of one-sided notions, and one should not insist strenuously that a child should eat certain things. If a child does not care for some particular food let him forget that he does not. Beyond teaching a child to eat rationally and slowly the question of diet is best let alone. Discussion of the subject ad infinitum is not conducive to mental health, and is the frequent foundation of severe hysterical dyspepsia in later life.

The life of the child should be simple and orderly, with the machinery kept well out of sight. Early hours up to the age of eight with a daily afternoon nap up to the age of six are imperative. Overstimulation, and overindulgence are equally bad, which is probably the reason why the lot of an only child or of one brother in a family of sisters is so frequently unhappy. The nervous child needs special physical and mental training which should never be intruded on his notice. Gymnastics and games in the open, sea bathing or lake bathing in the open all play a useful art. So also does the daily cold plunge, if not carried to extremes. A good rule perhaps is not to carry it beyond the child's enjoyment, which is a good index of his vim and energy. Play is useful but needs direction. The imaginative faculties of the child should be directed rather than stimulated. Here the mother can be of the greatest help, unless indeed she herself is hysterical in which case one has the combined forces of heredity and suggestion to fight against. Suggestion and imitation are practically identical in the life of the child, and if one can influence the parents to the soundest methods of training it is possible to elininate the most pernicious weeds that a bad heredity can sow. The ability on the part of the parents to be cheerful under all circumstances; to bear the petty annoyances of life with equanimity; to keep their worries and angers to themselves, is a constant stimulus in the right direction for developing children.

The school question is an important one, and should be decided by the physiological age of the child rather than by his years.

Wise education of the emotional life cannot be too strongly insisted upon, for the weakest point in the hysterical character is lack of emotional control. Consideration for the wishes and interests of others should be carefully instilled into their minds. They should learn to understand danger without fearing it, to know what hunger and cold are and to disregard them. Simply to tell them of these things is not enough. Real education demands that the opposing affective states shall be called up and self-control taught. The greatest value of games and athletics lies in the necessity for action and precision which provide a most helpful aid in controlling the sympathetic nervous system, the most important link in the emotional chain. The young boy or girl should be encouraged to dig, to build, to carpenter, to swim, to skate, to ride horseback, and works of phantasy should be kept in the background. As much as possible the energies should be directed to productive work, for the cultivation of efficiency and productivity affords the best antidote for the dreamy, hazy, inefficient, slipshod features of the hysterical character.

The reading of imaginative literature should be closely controlled, and highly exciting tales excluded. Hysterical adults would do well to avoid reading works that stimulate day dreaming, castle building, and the erotic.

The question of companionship for the child is of great importance, and should receive special attention. Nevertheless, isolation and solitary preoccupation are bad and it is better not to insist on too great perfection of environment than that he should be deprived of the companionship of others of his own age. Hence it is that good public schools and large private schools are often preferable to the small school. The latter may in some instances be useful in the case of normal children, but should not be chosen for the child with hysterical, syphilitic, or alcoholic antecedents, or for those who show the development of great emotional instability.

The avoidance of sexual factors for the young child is essential. Nature study is to be recommended as a means of gradual and natural education, which helps to avoid the distortion of sexual ideas at the approach of puberty.

Harsh methods should be avoided in the training of children who show a tendency to morbid anxiety, fears and self-consciousness as tending only to suppress their expression and possibly force the children into lying or hysterical conversions or defence reactions such as complaints of headaches or other physical ailments.

The principle of prophylaxis continues just as operative in the years after puberty as before, although the personality becomes more fixed and is modified with greater difficulty, but at no time can it

be said that one's ideas become so firmly settled as to be incapable of some change, at least if only the correct method of approach be found.

Etiological Therapy.—Stress must be laid upon the fact that many patients who develop hysterical symptoms, or who are the subjects of hysterical breakdown are not hystericals in the narrow sense of the word. In their case, some physical factor, or it may be some social overburden is the determining cause which brings out and accentuates the hysterical reactions with which we are all endowed. The diagnosis is not simple however, and care is necessary to determine whether the physical factor is primary or secondary. Here we would say a special word of warning as to gynecological disorders in women. It is certain that they are a frequent source of hysterical reaction even in the average woman, and under any condition when present must receive proper treatment. But, on the other hand, it must be remembered that major gynecological operations are often the direct cause of hysteria, and unnecessary gynecological operations are nothing short of criminal. Here the gynecologist should be warned particularly against those individuals, Dupre's "mythomaniacs" and others with strong hysterical tendencies who are obsessed with the idea of operation and are especially fond of consulting the gynecologist, and frequently, one regrets to say, succeed in gratifying their wishes. Gynecological operations have done much harm in hysteria and, particularly in the case of hysterical virgins, should be avoided in the absence of very definite and precise indications.

The sexual life of the hysterical and marriage in connection therewith are subjects upon which the physician is often called upon to express an opinion, and which are very difficult of decision. In spite of the popular theory, marriage does not cure hysteria, and, no matter what stand one takes on Freud's theories, it is certain that marriage as the answer is dangerous counsel for the hysterical. The argument that flighty young people settle down after marriage is no criterion, for there is a great difference between the hysterical character, and the so-called hysterical conduct of young people, especially of young women. Advice should be given in the form of free discussion after careful consideration of all the facts of the case obtainable including personality, heredity, environment and responsibility.

Gastric disturbance is another fruitful hysterical field which has been carefully cultivated by suggestion. Stomach disorders are perhaps the most common of hysterical manifestations, and care should be taken not to intensify them by faddy dietetics. Déjerine in his Psychotherapy (translated by Jelliffe, J. B. Lippincott & Co.) has much to say upon this subject.

Treatment of Developed Hysteria.—Psychotherapy is the best, one might almost say the only mode of treatment. Psychotherapy is capable of wide definition and includes the use of every means by which the patient may be helped to the attainment of self-control from the word of command which may relieve a child of an hysterical paralysis to the use of pragmatic philosophies and tactful dialectics, or the wise and careful psychoanalysis required in the treatment of a college professor or a refined and intellectual man or woman. General laws are impossible of formulation: the means must be suited to the individual and his social milieu, always bearing in mind that moral reëducation is an absolute necessity if one would have permanent results. Nevertheless the idea expressed by psychotherapy naturally fall into loose overlapping groups, the principal of which are *hypnosis*, *suggestion*, and *reëducation*.

Hypnosis has been modified considerably, and now implies a form of suggestion. In this modified form ideas are impressed upon the patient's mind while in a state of modified consciousness known as hypnotic sleep, the hypnoidal state, etc., and which is induced by some trick method. It is of importance to remember that not every patient can be hypnotized and attempts at hypnotizing those of higher intelligence are usually of no avail. It is doubtful if suggestion affected by this means is of much value in the case of the weakminded, or those whose hysteria is due to constitutional mental inferiority. It is in these subjects that absolute evil can be accomplished by hypnosis in the hands of the unscrupulous. The type of patients in whom hypnosis seems to work some real value are those whose susceptibility is an expression of the hysterical personality. Hypnosis may be an aid in gaining a foothold with these patients, but is not sufficient to cure severe hysteria. It should be used merely as a preliminary to reëducation lest in place of eradication, perpetuation of the reactions may be the result. The use of hypnosis as a means of therapy has lost ground greatly and has been rejected by many of those who at one time were its warmest advocates. It remains a strong card in the hands of the Indian fakirs, swamis of doubtful type, and charlatans of many brands.

Suggestion as a definite means has also lost ground as being unsatisfactory. It is no longer claimed that it can cure the hemi-anesthesia of a hemorrhage in the optic thalamus, a multiple sclerosis, or the palsy of a lead neuritis. As here used the term means the bringing about of an affect state by influences which are not apparent to the individual. It consists in inducing mental associations leading to the modification of the patient's emotional and therefore psychical state that will cause actions that make for a better adjustment. Suggestions enter consciousness, either perceived on the threshold, or on its margin, awaken ideas, associations and bring about action which has a compelling force on the individual who is probably quite unaware of the source of the influences. The wise suggestor knows how to appeal to every idiosyncracy of the individual and combines with suggestion, persuasion, and in some cases the use of the word of command. The hysterical bedridden paraplegic may get up and run in response to the suggestion carried by the cry of a child in danger; one may use persuasion in urging a patient day by day to walk, telling him that he is daily gaining strength and will soon be well; or a sudden emphatic word of command may induce a monobrachial hemiplegic to raise his arm. Appeals to the ideals, the desire for praise, vanity, even egotism may all be of use in bringing about the desired end of advance toward reëducation of the hysterical character which is essential. Modification of the personality must be brought about if a recurrence of the symptoms is to be avoided.

Reeducation.—This is the ideal therapy. It aims at bringing out all that is in the patient of good, and aiding him to attain independence of thought and action. Here again one must insist upon the necessity for individuality in treatment. For the weak minded perhaps it is waste of time and of money which had better be spent in placing the patient where he will be out of reach of possible harm; but to those of normal mental endowment much help may be given. If neurasthenic factors obtrude themselves, isolation, what is known as Weir Mitchell's rest cure, is advisable. This should preferably be carried out away from home, in some place where new scenes pique the curiosity and stimulate interest. In passing one should point out that the choice of a nurse or attendant for the patient is of the greatest importance, for on the cooperation of the physician and nurse the success of the treatment often depends.

The majority of patients need a rigid daily régime, the strictness of which is a part of their moral rehabilitation. Absolute rest in bed should be prescribed, the patient not being permitted to read or write or to see visitors. The visit of the physician should be a daily event, and he should bring with him each day something new for the mental diet of the

patient: perhaps a chapter of Job, a scrap of natural history, a bit of human experience, a thought from a poet or a problem of human conduct to be solved, anything that will give the patient something to work over and aid her in gaining a new and healthy point of view of life; something that will stimulate her moral fiber. The nurse must have the same point of attack, unobtrusively carried out, and above all a cheap and boisterous optimism is to be suppressed. For food, one should commence with milk—three or four quarts daily and rapidly rising to five, six, or more, as indicated by the stools and digestion. The bodily weight must be watched, as it increases books may be allowed, care being exercised in their selection so as to see that they do not contain ideas which would work in with the patient's hysterical reactions. At the end of from four to six weeks some latitude may be allowed as to diet and the receiving of visitors.

These general psychotherapeutic talks should take into consideration the emotional as well as the intellectual training of the patient, and in addition special days should be set apart for discussion of the more highly colored emotional features. These may have to be in the nature of a prolonged psychonalysis as worked out by Freud and Jung and their schools. Rules for these cannot be definitely worked out, as much depends upon the personality of the physician and the individuality of the patient. Much tact and wisdom are required.

Special mention should be made of the use of religious ideas and ideals. Since religion of some sort is a part of man, and has primarily to do with the question of life in a hereafter, it is certain that it plays an important part in the affect life of the individual. Therefore, religious beliefs and their foundations should never be lost sight of in an enlightened psychotherapy, and an appeal to religious motives and ideals is frequently of inestimable service.

Such mechanical aids as hydrotherapy, electrotherapy, pharmacotherapy, physicotherapy may be of assistance, and indeed are sometimes necessary to give physical tone, muscular activity, or to correct disturbances of visceral adjustments, etc. Iron, arsenic and strychnine are useful tonics, and the salts of alkaline earths usually in combination with the phosphates are quieting in excessive muscular irritability. Narcotics, analgesics and hypnotics should be used with almost excessive caution, and only for a short time.

Valerian and allied drugs have no specific value, but it is not impossible to find combinations of the volatile class of drugs that have symptomatic value in their definite tonic action of the sympathetic nervous system. The search for remedies having definite selective action on the sympathetic nervous system has only just begun. Bromide hypnotics may be useful in the treatment of hysterical delirium; hyoscine is rarely necessary. Parehyldehhde by reason of its unpleasant taste is one of the most useful of the alcohol hypnotics.

Analytic or Cathartic Method.—The method first termed "cathartic" by Breuer, and later worked out by Freud and clarified by later work under the term the "analytic method" is now better known as "Psychoanalysis." It is impossible clearly to describe this method within a small space, but it may be described as "talking it out," an unburdening of the patient's mental troubles; a scientific application one might say of the principles of the confessional. By gaining the patient's confidence, and permitting him to see his unconscious, the analyst seeks to overcome the resistances, to bring back to consciousness the disagreeable memories curtained by the hysterical reactions and thus throw light on the repressed wishes of which they are the realization. When this has been done, the first step on the road to a cure has been made, and reeducation becomes possible. Great tact, patience, and concentration are required as well as the power of gaining confidence. Every symptom has some meaning which it is the task of the analyst to reflect back to the patients as in a mirror, that they may see themselves. Every act, symbolic expression, or action; lapse in speech, mannerism, needs to be carefully noted and its bearing coordinated. Special attention should be paid to the patient's dreams, since in these, according to Freud, the unconscious or repressed consciousness is more apt to reveal itself. Freud's "Psychopathology of Every Day Life" and his "Significance of Dreams" are of great value in this connection, while Hitschmann's "Freud's Theories of the Neuroses" gives a clear exposition of his theories and technique. Jung's "Theory of Psychoanalysis" is also to be highly recommended.

It is of great importance to trace back the patient's emotional life to his earliest years since as psychoanalysis is showing, it frequently happens that some childish experience, the memory of which has been repressed and pushed back, has laid the foundation for the hysterical reaction. Forgetfulness is the normal means of blunting the pain of an emotional strain, especially when the stress has not been to great, or when such reactions as tears, anger, impulsive acts, etc., or talking the thing over effect a discharge. At times, however, there is no adequate reaction (Freud's abreaction.)

The shock caused by the loss of loved ones, cannot be removed by discussion, social relations may make mention of the shock impossible, or there is something which the patient wishes to forget, These things are not given voice to, but are thrust back, repressed and overlaid by some hysterical reaction. The experience itself may be forgotten but the emotional scar remains. The physician working by this method aims to bring the underlying factors into the open, and remove the cause for the reaction.

There is no doubt that the method is of the greatest value in the great majority of cases, especially in those patients whose intellectual powers enable them to follow the process with intelligence. Freud has written voluminously on the subject, and a careful study of his works should be made as preliminary to any attempt at analysis. See article on *Psychoanalysis*.

SMITH ELY JELLIFFE.

Ichthargan, ichthyol silver, silver thio-hydrocarbosulfonate, is a brown, odorless, amorphous powder of neutral reaction, containing thirty per cent. of silver and fifteen per cent. of sulphur. Its odor is wanting, or slight, suggesting chocolate, and it is somewhat sternutatory. It is easily soluble in water, glycerin, or dilute alcohol, slightly soluble in ether or chloroform, and insoluble in absolute alcohol. On exposure to light it is slowly decomposed, so must be kept in dark bottles. It is precipitated by sodium chloride or albumin, the latter precipitate dissolving in excess of albumin.

This drug is more strongly antagonistic to anthrax, gonococcus, and other bacteria than is silver nitrate. Lohstein uses it in gonorrhea as an irrigation in 1 to 4,000 to 1 to 2,000 strength. Leistikow uses a 0.02 to 0.2 per cent. injection. For posterior urethritis Fürst employs an instillation of six to ten drops of three per cent. solution. As a prophylactic following suspicious coitus he instils three or four drops of a ten per cent. solution. It is said to be much less irritating than silver nitrate, and to be followed by no desire to urinate. Unna says that, unlike silver nitrate, it does not favor granulation, but favors rather the production of epithelium. The best results are obtained in clean ulcers and in old hard ulcers with callous margins after the horny layer has been removed by salicylic plaster mull. It is a strong astringent for indolent, edematous, or hemorrhagic granulations. Falta uses a half to three per cent. solution for granular conjunctivitis.

W. A. BASTEDO.
R. J. E. SCOTT.

Ichthoform is a blackish-brown, amorphous, almost odorless and tasteless powder, resulting from the action of formaldehyde on ichthyol. It is insoluble in all ordinary solvents. Aufrecht has made a comparative study on bacteria and animals, especially frogs, rabbits, and dogs, and finds it to have a greater antiseptic power than iodoform and analogous compounds, and to be comparatively innocuous. Goltmann uses it locally for endometritis in ten per cent. glycerin mixture on tampons, and as a deodorizer in ozena. Internally he employs it in atonic or functional digestive disorders. Five grains (0.35) may be given every three hours for acute gastro-enteritis and intestinal tuberculosis, in which conditions it is highly recommended. Polacco employs grains viii. (0.5) in capsule up to twelve capsules a day for enteric fever. It has no action on the nervous system, and its continued use in large dose is said to be without effect on the kidneys. In conditions of indicanuria with headache and malaise, its administration is quickly followed by disappearance of the indican from the urine and the relief of the symptoms. On account of its irritating properties in vaselin mixture, Unna prefers it made up with zinc ointment in one-per cent. strength as an application in eczema capitis of children, psoriasis, eczema of seborrheic origin, and in pityriasic forms of eczema. As its hardening powers lead to superficial necrosis, it can be used only in affections which tolerate the desquamation of the horny layer.

W. A. Bastedo.
R. J. E. Scott.

Ichthyocolla.—Isinglass. The swimming-bladder of *Acipenser Huso* Linn., and of other species of *Acipenser* (Class, *Pisces;* Order, *Sturiones*).

Isinglass is prepared from these sturgeons, mostly of the tributaries of the Black and Caspian seas where they are very largely consumed for food, by opening and removing their air reservoirs, splitting or slicing them, macerating them to remove their mucous surfaces, and drying; the tripe-like membranes are then rolled in cylinders (staple isinglass), folded in folios (leaf or book isinglass), or done in some other more or less fantastic shape. Its ordinary form in this market is that of "sheets," of irregular size and shape; it is stiff, of a thorny or pearly appearance, whitish color, semitransparent, somewhat iridescent, tough, and flexible, but without taste or odor. Isinglass almost completely dissolves in boiling water, the structural character disappearing completely. Besides this, which is generally known as Russian isinglass, and is in this country very expensive, the swimming-bladders of the hake and other fishes are manufactured into sheets and ribbons of thin, light-brownish, gelatinous tissue, known as American isinglass. Its properties are similar to those of the above, but it is darker colored and not so absolutely free from taste and odor.

Isinglass consists of about ninety-nine per cent. of pure, white, fine, and adhesive gelatin, which forms a jelly with twenty-four parts of water. Its medical and dietetic qualities are identical with those of other pure gelatins, which are frequently substituted for it. Its only medical use is in the preparation of water plasters (isinglass plasters, court plasters, etc.), which are essentially silk or linen cloth, varnished with a thin layer of the isinglass, and backed with some waterproof varnish, like that of gutta-percha or tolu.

Such a plaster is official under the title *Emplastrum ichthyocollæ*.

Japanese isinglass has already been considered under *Agar-agar*.

H. H. Rusby.

Ichthyol.—This is the trade name of a compound described as ichthyosulphonic acid in combination with ammonium. It is obtained by the distillation of a bituminous mineral deposit of the Tyrol, which contains an abundance of the fossil remains of fish and other marine animals. During dry distillation there passes over, between 100° and 225° C., a mixture of crude volatile oils, which when treated with an excess of concentrated sulphuric acid, forms ichthyosulphonic acid. The product, in addition, contains an uncertain percentage of unchanged oil.

Ichthyosulphonic acid forms salts with ammonium, sodium, zinc, lithium, calcium, iron, silver, and various other metals. The ammonium salt is that to which is given the title ichthyol.

Ammonium-ichthyol-sulphonate is a thick, brownish fluid, with a smoky bituminous odor and taste. It is soluble in water, oil, glycerin, and a mixture of alcohol and ether. Its virtues are ascribed to the large amount of sulphur that is present, about sixteen per cent. The therapeutic value of ichthyol depends upon three factors: its antiseptic action, a contractile effect which it exerts on the capillary vessels, and its reducing property. It is stated to be free from any toxic action, but an instance is recorded in which the applications of one part of ichthyol to two parts of glycerin, to the curetted surface of the uterus, produced very alarming symptoms. The patient complained of the taste of the drug, tachycardia, and depression, and remained prostrated for twelve hours.

It was introduced in 1883, by Unna of Hamburg, as a remedy for the treatment of various forms of skin disease. He advised fifteen drops twice a day internally, and a ten-per-cent. lotion to be painted on the affected part. In eczema and other forms of skin disease he advised it to be used more cautiously and in weaker solutions. In all these conditions its internal administration was advised, as it is supposed to possess valuable alterative properties. Ichthyol has come into very extensive use for all forms of skin diseases, and for the removal of the products of inflammatory processes. It has proved most serviceable as a local application in erysipelas. Locally it is applied as an ointment of the strength of five to ten or fifteen per cent. A varnish of ichthyol is a favorite method of using the drug. It is made of ichthyol ten parts, starch forty parts, solution of albumin one part, and water to 100 parts. The starch is mixed with the water, the ichthyol is then well rubbed up with it, and lastly the albumin is added. For inflammatory deposits stronger preparations are employed; ointments containing fifty per cent. may be used, or a mixture of ichthyol and glycerin is applied and the part is covered with lint and bandaged. Ichthyol plasters and ichthyol wadding may also be obtained.

The remedy has not been much used in general surgery, but in gynecology it is a favorite application in all uterine and vaginal inflammations. It may be applied in a glycerin solution, or in its pure state on tampons, or medicated pessaries may be introduced after antiseptic and astringent douches have been used. When gonorrhea is a factor the drug is thought to be especially beneficial.

Beaumont Small.

Ichthyosis.—Definition.—Ichthyosis is a congenital cutaneous deformity in which the skin is dry and rough and the epidermis thickened and scaly. Although congenital its lighter forms are by no means infrequent.

Etiology.—Almost all observers agree in regarding ichthyosis as a congenital disease, and the arguments in favor of this view are: That the disease commences early in life, endures throughout life, is only temporarily benefited by treatment, and immediately recurs on the cessation of treatment; that the disease is not inflammatory, as infective and toxic diseases are, but acts more like an anatomical deformity; that it is often a family disease, two or more brothers or sisters being frequently similarly affected, and even when

the immediate family is free, more distant relatives may be found afflicted.

It is hardly necessary to draw attention to how characteristic this skipping over individuals is in hereditary affections, one or two members of one branch of a family and one or two of some other branch being picked out, the rest escaping. Nevertheless it must be admitted as remarkable how frequently cases of severe ichthyosis are reported in which the parents are said to be perfectly healthy, and this has been noted even when several of the children have ichthyotic skins.

An objection has been raised to calling ichthyosis a congenital disease, because it usually does not appear until the second or third year of life, although

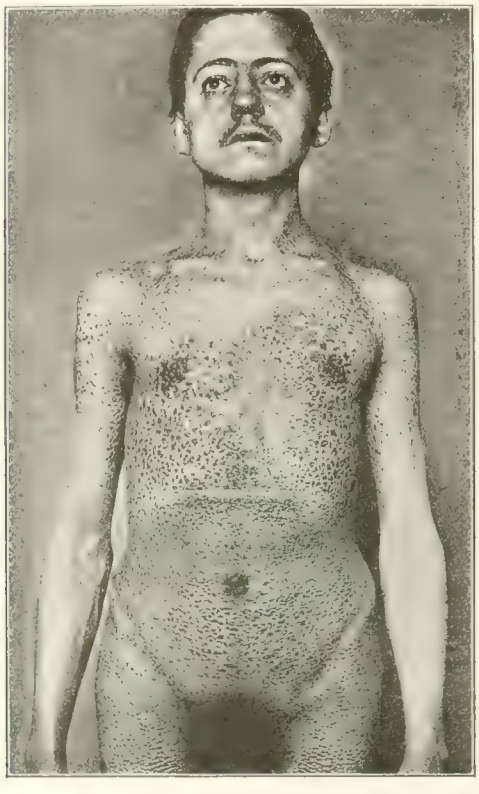


Fig. 3370.—Ichthyosis. (From A. Neisser's "Stereoscopischer medicinischer Atlas".)

it may manifest itself in the third or fourth month. This, however, is not a valid objection, because ichthyosis agrees exactly in this particular with other congenital deformities. Nevi, for example, although certainly congenital, frequently do not appear until a considerable time after birth; not, indeed, until the gradual development of the affected individual or the growth of the lesion itself brings the blemish to view.

Undoubtedly ichthyosis depends in a great measure on defective action of the sweat and sebaceous glands. Three of its features point decidedly in this direction, viz., the dryness and lack of unctuousness of the skin; the improvement of the symptoms during the summer months when the sweat glands are most active; and the tendency to the localization of the disease in those parts where the sweat and sebaceous glands are least active, as on the extensor surfaces of the limbs, leaving the articular folds, such as the bend of the elbows, the axillary, inguinal, and popliteal folds, and the skin of and about the genitalia, unaffected.

Although ichthyosis is an hereditary and congenital affection, yet it probably may be accentuated by diseases which are not in their true sense hereditary. Syphilis is not in the true sense of the term an hereditary disease. What we call hereditary syphilis is an "infective disease" caught by the fetus during gestation. The way that syphilis, for instance, may possibly accentuate ichthyosis is shown by two cases reported by Gaston and Emery. The father of these children had a slight ichthyosis and also had syphilis. The children acquired syphilis congenitally, and became after birth markedly ichthyotic. Besides ichthyosis, however, the children had microsphygmia, and the authors entertained the opinion that the small pulse was owing to a generalized, congenital, syphilitic arteritis, and that this affection of the arteries so interfered with the nutrition of the fetus as to accentuate the hereditary tendency to ichthyosis.

Recently Edward Fournier has collected from the literature nine cases, and has added one of his own in which patients having hereditary syphilis also had ichthyosis. The author clearly states, however, that he does not believe ichthyosis to be a symptom of hereditary syphilis, but explains the coincidence by the theory that hereditary syphilis is at times one of the causes of degeneration in the individual, and that ichthyosis is a symptom of degeneration.

Interesting, particularly in its connection with treatment, is the relationship between defective development of the thyroid gland and ichthyosis. As one of the symptoms of cachexia strumipriva is a rough dry skin; a mistake in diagnosis might easily occur, or defective action of the thyroid gland might accentuate an already existing ichthyosis.

Symptoms.—As ichthyosis is a congenital deformity there are necessarily all grades of it, from almost inappreciable manifestations up to disgusting monstrosities. Dryness of the skin and desquamation are, however, never absent in ichthyosis, and in fact in the most attentuated form of the disease, in xerodermia, extreme dryness of the skin, a very fine desquamation, and obstruction with epithelial cells of the pilo-sebaceous orifices are the only symptoms present. It is this last symptom, the accumulation of epithelial cells about the points of emergence of the hairs, that gives those having ichthyosis their "goose-flesh" appearance. This same permanent "goose-flesh" appearance constitutes the disease called keratosis pilaris, and it is because the same appearance is produced by the same kind of plugging of the same orifices, and also because the favorite situation of both keratosis pilaris and ichthyosis is on the extensor surfaces of the upper arms and thighs, that some authors regard keratosis pilaris, when it exists alone, as constituting the very lightest form of ichthyosis, even lighter than xerodermia.

Of the two symptoms, dryness and desquamation, Thibièrge considers dryness the more essential, even thinking dryness without desquamation often indicative of ichthyosis; therefore he would classify congenital permanent anidrosis as a form of ichthyosis, and this for the following reasons: In both diseases the skin is unusually dry, both are congenital, both occur in families as hereditary diseases, and some members of the same family may have anidrosis while others have ichthyosis. He thinks that many cases of ichthyosis which are supposed to develop during adolescence or later, are simply cases in which anidrosis was at first the sole symptom and which remained comparatively unnoticed, the more disagreeable symptom of scaliness supervening later.

Apart from the two general charcteristics of dryness and a tendency to adhere and form masses, the superficial epithelium in ichthyosis shows many variations. It is sometimes powdery, and the cheeks for example may look as if dusted with white face powder; this constitutes a variety of the pityriasis simplex of

some authors. This form of ichthyosis when more marked shows a diffuse powdery, chalky white coating, which is particularly apt to show itself on the outer surfaces of the upper and lower extremities. Instead of the powdery condition there may be scaling, and the scales may be clear gray or grayish-black, thick or thin, lusterless, hard or soft, but as above stated they frequently show a tendency to adhere with their flat surfaces tightly to one another, sometimes forming thick, uniform, lamellated, corneous masses. When the epidermis accumulates in thick horny masses as it does in ichthyosis hystrix, pigment may develop in it, which may be a dirty green, a bright green, dark green, or greenish-black. The green may be so bright as to be startling, even artificial looking. The edges of the scales may be separated from one another by little furrows, or they may overlap like fish scales. Sometimes the surface of the skin looks like the finely crumpled tissue paper called crêpe paper used for lamp shades, where the ridges run in every direction, crossing one another and dividing the surface into a vast number of quadrilateral areas. The wrinkled epidermis in such cases looks as if too large for the cutis. Sometimes instead of there being ridges there are fine shallow cracks, passing through the superficial layers only. These cracks fill with dirt, and just as under the finger nails, this dirt assumes a dirty greenish-gray color, marking the skin off into lozenge-shaped areas by a dirty greenish-gray network. The lines may crack down deeper than indicated above, and the superficial epidermis may be broken and upcurved along the edges of the enclosed lozenge-shaped areas resembling the bark of some trees. The surfaces of these lozenge-shaped areas may glitter and reflect light resembling a facetted reptilian skin. Sometimes the surface looks unnaturally smooth and polished, with lines running across it at all angles, as if the surface had been varnished or had collodion poured over it, and had cracked in the drying.

Frequently the skin does not crack, but has running across it a vast number of criss-cross furrows dividing the surface in the same way into quadrilateral or irregular areas. These furrows are really the natural markings of the skin exaggerated, and are frequently chalky white and powdery; in such skins if the finger nail be drawn sharply across the surface it will leave a chalky white, crumbly, permanent mark.

Sometimes the papillary layer of the skin is hypertrophied, and when this occurs, and corneous masses or spines are formed over the papillæ one of the varieties of ichthyosis hystrix results. Another variety of such horny spines is formed by a great accumulation of the epithelial cells projecting from the pilo-sebaceous orifices, constituting the keratosis pilaris above named; this occurs generally on the extensor surfaces of the arms. Ichthyosis hystrix is never universal, although it may occur over large tracts of the skin. Usually it occupies only certain regions, while the intervening skin is xerodermatic. A child at present under treatment in the University Clinic has ichthyosis hystrix only on the ankles, while other regions show several different varieties of ichthyosis. This condition of ichthyosis hystrix, literally "hedgehog fishy disease," is considered particularly undesirable in a bed-fellow.

The true skin may be atrophied, tightly stretched, and thin, and the subcutaneous fat layer be thin and poorly developed.

The face usually shows only a light grade of xerodermia. It may have a polished shiny appearance, and the cheeks may be red and blooming (Jadassohn). The palms and soles are dry and powdery but not scaly, with the furrows more marked and more numerous than normal, and this condition may remain after treatment has improved the skin in every other locality. There may be hyperidrosis of the finger tips accompanying the dry palms.

The hair is frequently normal, of good color, luster, quality, and quantity, but it may be dry, frail, and thinly scattered, constituting an expression of the same fault of development that gave rise to the ichthyosis. Sometimes there is nearly complete alopecia, even the eyebrows and eyelashes being almost entirely absent (Thibièrge). The nails are usually strong and in every way normal. They may, however, be thin, brittle, and either transversely or longitudinally ridged, or there may be an accumulation of dry, brittle, corneous substance under them.

These patients sometimes give off a flat, stale, penetrating, disagreeable odor, such as is met with in other cases of generalized hyperkeratosis with maceration of the epidermis, as in Darier's disease for example (Thibièrge).

Pruritus is not a symptom of ichthyosis, but it is a symptom of eczema to which the ichthyotic patient is predisposed. Frequently the ichthyotic patient is sensitive to cold, chilly feelings being experienced on the slightest lowering of the atmospheric temperature.

A patient usually presents examples of a number of the conditions enumerated above; for instance, the hair may be good, but the scalp is usually in a condition that cannot be distinguished from dry seborrhea. The outer surfaces of the arms and thighs and the skin of the trunk may be dry and scaly and criss-crossed with furrows, and studded with dry papules that look like "goose flesh." The buttocks and upper portions of the thighs may be covered with "crepe-paper" skin. The roughness of the skin increases down the extensor surfaces of the thighs until over the front of the knees one finds immense corneous masses. Below the knees the skin may be tightly stretched over the tibiæ, smooth, shiny, and with markings on its surface dividing it off into small quadrilateral areas.

Course and Duration.—Usually ichthyosis does not become appreciable until the second or third year of life, although cases have been reported in which the malady was apparent at birth or shortly after. The first symptom, according to Peukert, is the appearance of keratosis pilaris that shows itself on the extensor surfaces of the extremities in earliest childhood in these individuals. It is simply this early appearance of the keratosis pilaris and its greater development later in life that distinguish it at all from the ordinary form of keratosis pilaris. Ordinary keratosis pilaris of moderate development is so common later in life, especially at adolescence when the lanugo hairs begin to sprout more vigorously, that it is practically a normal condition. Ichthyosis continues to grow more marked from two or three years of age until adult life, when it may remain stationary or subject only to the mutations of the seasons, becoming severe in winter and milder in summer, till the natural dryness and harshness of the skin of old age again accentuate it. In summer, in fact, the plates, scales, and fluffy epidermis may all fall off as a "moulting," leaving the skin almost normal. Sickness and a lowered condition of health may also increase the dryness and harshness of the skin, and there is reason to believe that inactivity or absence of the thyroid gland can contribute decidedly to the severity of the symptoms. The symptoms of ichthyosis may disappear completely after one of the eruptive fevers, measles for instance (Joseph), only to reappear in a short time, however. This same amelioration may also occur during pregnancy.

Quinquaud has reported a case in which the patient got an ichthyotic skin following a generalized eczema of two years' duration. He says that such acquired ichthyotic states may after a time disappear. It is doubtful, however, if such ichthyotic states as described by Quinquaud should be included in the disease ichthyosis at all.

Unna and Tommasoli believe that ichthyosis is an acquired disease that has its time of onset, development, and disappearance, but this view finds very little support among other observers.

Unusual Symptoms and Course.—The flexures of the articulations, particularly the axillæ, the bends of the elbows, the groins, the scrotal thigh folds, and the poplitea are usually unaffected. In fact, Georges Thibièrge would make the freedom of those localities a sharp diagnostic feature. Recently, however, a number of cases have been reported in which one or several of these localities have been affected, and there happen just now to be in the University Clinic two patients in whom the axillæ, the groins, the scrotal thigh and vulvar thigh folds respectively, and the politea are affected, as shown by the presence of pityriasis. In both patients there is an eczema of the upper extremities that involves the bends of the elbows, making it impossible to say whether these are ichthyotic or not. The appearance and stubborn character of the eczema, however, would lead one to infer that the condition is also present there. Joseph has reported a case in which only the flexures were affected. Usually ichthyotic patients do not sweat, but Peukert thinks the dryness of the skin is in some cases not due to lack of perspiration, but to an increase of evaporation from the more extensive cutaneous surface of these people. In some instances there is vicarious sweating of certain regions, as of the face for example (Goldzieher), or of other regions not implicated in the ichthyosis, as the axillæ or the palms and soles. This sweating may be abundant. The mucous membranes are rarely affected in ichthyosis, unless the susceptibility to catching "colds" and to bronchitis be looked upon as the particular way they show their inherent weakness. There are atrophic forms of the disease, which Hallopeau considers simply an exaggeration of the form in which the skin is like crepe paper. The skin is very thin and has little elasticity, so that when pinched it retains the impress of the fingers for a long time. The skin may appear too large for the patient, or on the contrary it may be too small, not permitting the closure of the eyelids, exaggerating the cutaneous folds, especially in the movements of the facial muscles, and impeding the flexion and extension of the fingers. In two of the cases so reported the skin seemed glued to the subjacent aponeurosis. Kaposi has shown a case which he called ichthyosis hystrix pterygoides s. plumiformis, in which there were hundreds of little growths from 0.5 to 1.5 cm. long that looked like feathers. These growths consisted of a central core of connective tissue with tufts of cornified epithelial tissue depending from them. The patient was a girl six years of age and the palms and soles were thickened, cracked, and warty. This case stands alone in literature, and it is not at all certain that it should be included among the ichthyoses.

Those having ichthyosis and those that are scrofulous have in common a tendency to inflammation of the respiratory tract, and besides that, Unna has noted with great particularity in one of his cases an unusual growth of hair down the cheeks in front of the ears. An unusual growth of fine downy hair in this situation was considered by the late Professor Horner of Zurich a symptom of scrofula. He used frequently to say, "They, the scrofulous, all wear a beard." A little girl suffering from ichthyosis, formerly attending the University Clinic, had quite a little beard of fine long hair growing down in front of each ear.

Diagnosis.—The first disease to be sharply differentiated from ichthyosis in nevus linearis, and this is not because there is any great similarity between the diseases, but because some writers persist in describing nevus linearis under the name ichthyosis hystrix. Nevus linearis is a warty congenital disease, in which the warts are frequently covered with horny masses, but here the similarity ceases. Nevus linearis occurs in lines or in localized areas, and is usually asymmetrical, and the skin between the patches or lines is absolutely normal. In ichthyosis the disease is symmetrical, and almost always the whole skin is affected, with the exception of the folds of the articulations. Another good point of differentiation lies in the fact that nevi, nevus linearis included, have generally a buff or a slate-colored pigmentation, and the pigment lies in the connective tissue of the skin, usually in the affected papillæ, while if there is a black or other color in ichthyosis, it looks more like dirt in the horny layers or pigment in the epithelium, rather than like pigment in the papillæ or in the true skin. In ichthyosis the palms and soles are almost always unnaturally dry with a powderiness of the surface, while in nevus linearis the palms and soles are normal, when not directly the seat of the nevus, which they rarely are. Furthermore nevus linearis does not attack several members of a family, but occurs irregularly here and there throughout a community; in other words it is not a family disease.

There is another disease, however, which is hereditary, which occurs in families, and which consists of an exaggerated development of the horny layer of the skin. This disease, keratoma hereditarium palmare et plantare, it seems desirable to keep separate from ichthyosis. This is all the more difficult to do because, besides the above points of similarity with ichthyosis, there is also in ichthyosis thickening of the horny layer of the palms and soles. In keratoma, however, the thickening is limited sharply to the palms and soles that are often surrounded by a border, four or five millimeters in breadth, of a reddish, bluish, or violet color. There also may be increased action of the perspiratory glands of the affected surfaces. It therefore lacks the generalization of ichthyosis and also the dryness, two important features. Furthermore, in keratoma the thickening of the horny layer of the palms and soles is frequently much greater than even in the severest forms of ichythyosis. Joseph suggests that this keratoma may really be ichthyosis, in which a "moulting" process similar to that which takes place in some patients every summer, has taken place *in utero*, over all the surface excepting the palms and soles, leaving those parts alone affected.

The atrophic form of ichthyosis resembles somewhat the lesions found in the skin in some cases of scleroderma. It differs from scleroderma, however, in the absence of induration and of interstitial cicatrices, and also in the fact that it does not progress.

There are a number of desquamative inflammatory diseases of the skin, such as psoriasis, pityriasis, exfoliative dermatitis, and the dry eczemas, which differ from ichthyosis both in their course and in the fact that they are accompanied by inflammatory symptoms.

Georges Thibièrge at one time demonstrated a case as ichthyosis in which there were immense irregular horny masses distributed symmetrically in various regions of the body, but principally on the face and on the palms. There was almost no hair on the scalp. The buccal and nasal mucous membranes were thickened and furrowed, and there was a grayish infiltration in the superficial layers of the center of each cornea. Latterly he has concluded that this case was analogous to one in which Giovannini had found the epidermal alterations principally about the orifices of the sweat glands. As the affection was congenital he gave it the name congenital disseminated porokeratosic hyperkeratosis, instead of ichthyosis.

For the diagnosis between ichthyosis and ichthyosis fetalis the reader may consult the article on this latter subject.

Those who are reduced by a chronic disease may get a fluffy scaliness that is called pityriasis tabescentium. It differs from ichthyosis in that it develops and disappears with the development and disappearance of the cachexia. A similar condition occurs in old age.

A number of diseases of the nervous system are accompanied by atrophy and desquamation of the skin similar to ichthyosis. These ichthyotic states are distinguished from ichthyosis by their occurrence only on the skin supplied by the affected nerves.

Pathological Anatomy.—The principal lesion found in ichthyosis is a hyperkeratosis of the superficial layers of the epidermis, with atrophy of the deeper layers. The papillary layer is less developed than normal. The muscles bundles are hypertrophied. The keratosis pilaris can be seen to be due to plugs of cornified epithelial cells in the pilo-sebaceous orifices. Thibièrge says the orifices of the sudoriparous glands are free, but the sweat glands themselves and the sebaceous glands are frequently atrophied and cystic. The hair follicles may disappear and the hairs may atrophy. The papillary layer and the superficial layers of the derma show evidences of inflammation, which however, are nothing more than one would expect from the irritated condition of the skin.

There is a question whether the green color developed in the epithelium in ichthyosis hystrix is true pigment, or dirt caught in the interstices of the epithelium. In the child at present under treatment in the University Clinic the green color is quite vivid, but when the epithelium in peeled off, as it can be in masses, the color is seen to be very superficial. It must also be remembered that when dirt is allowed to accumulate under one's nails, it has the same dirty olive-green color as in ichthyosis hystrix.

Treatment.—It must not be supposed that, because ichthyosis is a congenital defect and therefore not permanently curable, treatment is useless. Much may be done to ameliorate the condition, and it is important to know this as the lighter grades of ichthyosis are quite common. Ichthyosis is important in another way as an ichthyotic skin is especially inclined to eczema, and eczema in such individuals is especially difficult to treat. Residence in a hot climate would be beneficial, as a spontaneous amelioration takes place in warm weather; but, of course, for many patients this is impossible. Frequent hot baths bring about the same result by increasing the activity of the sweat and fat glands, and in fact hot baths are indispensable in any plan of treatment. If a quick temporary effect is desired, jaborandi or pilocarpine may be given on account of its action on the sweat glands, but of course its continued administration would not be advisable.

Besides pilocarpine and jaborandi the internal use of many remedies has been advised, but they have very little effect on the malady, with the exceptions perhaps, of cod-liver oil and arsenic. Sulphur, the balsams, mercury, and many other drugs have been recommended but have been found to be of no avail. In some instances it is rational to suppose, and is by many believed, that arsenic in small doses does good. Arsenic in the form of Fowler's solution may be given in cod-liver oil emulsion.

As some cases of ichthyosis have been reported in which the thyroid gland has been found much diminished in size, and as roughness and desquamation of the skin are symptoms of cachexia strumipriva, it naturally follows that thyroid extract would be recommended. Jadassohn has never found it to do any good, and I have never seen a case where it seemed to me rational to prescribe it.

Ehrmann, following out the idea suggested by Tommasoli that ichthyosis is due to an autointoxication, gave menthol internally in one case. He reported that under its influence the desquamation ceased, but the criss-cross lines persisted.

External treatment is of course what one must rely on. Hot baths, soft soap, and a good nail brush to get rid of the superfluous epithelium, and after the bath the inunction of a lubricant well rubbed in to assist in maintaining the skin soft and supple, constitute the principles of treatment. The hot baths must not be given too frequently and their effect on the patient must be watched, as in some cases they are debilitating. The choice of the lubricant is also not a matter of indifference; for instance, cod-liver oil is acknowledged to be one of the best softeners of epithelium, yet its odor makes the patient more disagreeable to a larger circle of his acquaintance than the disease itself.

The treatment advocated by Lailler is one of the most effective and pleasant, and deserves the praise that Georges Thibièrge has given it. It consists in giving a hot bath with soft soap and plenty of friction three times a week in order to remove the epidermal masses, and morning and evening prolonged and light massage of all the affected parts with glycerole of starch made in the following way: ℞ Amyli pulv., 15; Glycerini, 150. Mix and heat in a porcelain dish over a slow fire, stirring all the time, until the mass is about to jelly, when 15 c.c. of cherry-laurel water is added.

One can add to this one or two per cent. of salicylic acid, which has the effect of still further softening the skin and aiding desquamation. After a time one inunction a day will be sufficient, and when the skin has assumed its normal appearance Lailler says that one hot bath with soft soap a week, followed immediately with an inunction of the above glycerole of starch, or even of pure glycerin is enough to maintain a normal suppleness of the skin.

It is important in using the glycerole of starch or pure glycerin that only a moderate amount should be applied so that the skin on finishing is supple and unctuous, but not gluey. Neutral glycerin only should be used. The advantages of the glycerin treatment are: That the glycerin itself is favorable to maintaining the moistness of the skin through its affinity for water; that even the slightly fat odor that glycerin has can easily be overcome by the odor, say, of cherry-laurel water; that it does not soil the clothing as the greases do, and does not render the clothing difficult to wash; and that it does not become rancid. Instead of using glycerin in the form of glycerole of starch, pure glycerin may be added directly to the bath. About six or eight ounces of glycerin may be added to each bath, and two or three baths a week may be taken.

Instead of adding glycerin to the bath, bicarbonate or biborate of sodium may be added, say one or two tumblerfuls of the powder to each bath. Vapor baths are enjoyed by some patients, and they are efficacious. Starch poultices with boracic acid added to them, a heaping teaspoonful of boracic acid to a small bowl of starch paste, are an excellent means of loosening up epithelial masses.

Prognosis.—Ichthyosis as a deformity is not dangerous to life. When it is very marked it represents an extensive developmental fault in an important organ, and is accompanied by a corresponding lack of resistance. People so afflicted are frequently puny and illy developed in many directions, and may have bad nails, teeth, and hair, and may lack the normal quantity of subcutaneous fat. They easily become chilled and catch cold, and many of them end with tuberculosis (Lewin). Those having the lighter grades of ichthyosis, and they are by far the more numerous, are perfectly healthy, normally plump, and have good hair, nails, and teeth. Their only disadvantage is a rough dry skin, sensitive to cold, and inclined to become eczematous. If the scalp is neglected the hair may fall and they may become prematurely bald because of the pityriasis.

Douglas W. Montgomery.

Ichthyosis Fetalis.—Definition.—Ichthyosis fetalis is an anomaly of development accompanied by consecutive malformation of certain parts of the face, and should be included in the same group with the nevi. Ichthyosis fetalis must not be confounded with ichthyosis vulgaris, with which it has nothing whatever to do except in being congenital, and in being a family disease. It is for this reason that the word ichthyosis in the name of this disease is unfortunate and leads to confusion. Very probably a better name would be hyperkeratosis fetalis.

The disease is very rare, and even of those children who are born with it, but few come under the observation of men interested in skin diseases, as they usually die shortly after birth. Only a few of these cases have been reported, and of those few, it has several times occurred that one mother has had more than one child so afflicted. Excepting this fact of its being in many instances a family disease, very little is known of its etiology. Bowen attributes the condition to the persistence of the epitrichial layer. The epitrichial layer of epithelial cells occurs in some animals, and Bowen thinks that it is present at one stage of fetal development, but subsequently, under normal conditions, is shed.

Symptoms.—The epidermis has a dirty yellow, leathery appearance, and is thickened, and the skin looks too small to contain the infant. In fact it looks as if the infant had been covered by a much thickened and inelastic epidermis, and that in growing it had burst this coating, forming cracks in it running into one another at all angles. These fissures or cracks are more or less red, and about a centimeter wide, and they may or may not be covered by a thin epidermic layer; when not so covered the raw surface lies exposed, and it soon suppurates abundantly.

In addition to the deformity of the skin there are other deformities present, such as congenital ectropion in which the lids look like red projections hiding the globes of the eyes completely. There are neither eyelashes nor eyebrows and in fact the whole pileous system is very badly developed. The hair, however, though thin, grows very quickly, as do the nails (Thibièrge). The nose is flat to the face and is represented by two rounded holes, and the cartilaginous septum is entirely lacking. The lips are thickened and are cut by radiating fissures, or they are entirely absent and the skin of the face may run over directly to the gums. The ear shell is represented by a flattened plateau with a central rounded hole, the external auditory meatus. There are no nipples on the breast, the anus may be imperforate, and the external genital organs are imperfectly developed. The fingers and toes are often bent and clawed, and give the impression of being hidebound, more or less soldered to one another, or they may be entirely absent, the extremities terminating in rounded masses.

The reasons for thinking that the fetus at one stage of its existence is completely covered with this inextensible horny envelope, which afterward is burst open, are that the direction of the fissures is in all cases about the same, and is such as would be occasioned by the growth of the enclosed fetus; that the furrows at birth are partially or entirely covered with a thin epidermal layer, which represents the healing process after the bursting has taken place; that the hair follicles are entirely absent from the center of the furrows, while on the sides the hair follicles are directed outward as would result from tearing the plastic fetal skin asunder (Peukert); and that the deformities at the orifices of the body, the absence of the eyelids and of the lips, the flattening of the nose and of the ears as well as the deformities of the hands and feet are such as would be occasioned by the fetus being hidebound.

Infants with such severe lesions die inevitably, and usually in two or three days after birth. They may not be able to take food at all, because of the malformation of the lips, or they may die from the suppuration in the cracks of the skin, or from bronchitis or pneumonia. Attenuated forms of the disease have been reported, however, in which the patients have lived for years. The mouth seems to be the chief factor in determining the prognosis, as those having a badly formed mouth die of inanition.

Diagnosis.—Ichthyosis fetalis differs from ichthyosis vulgaris in the time of its appearance, ichthyosis fetalis being apparent in the fetus and in the new-born babe, while ichthyosis vulgaris is rarely evident before the second or third year of life. Ichthyosis fetalis is almost always associated with malformation of the ears, eyes, and lips, and frequently with other malformations. It is rare for ichthyosis vulgaris to be associated with any other malformation whatever. Ichthyosis vulgaris has its regions of greatest development, and it rarely affects the folds of the articulations, but if it does affect them the disease in such situations is very mild. In ichthyosis fetalis on the contrary, the disease is as severe in the articular folds as anywhere else. Furthermore, in ichthyosis fetalis the epidermis is not alone thickened, but it is also abnormally resistant and inextensible. In ichthyosis vulgaris the absence of sweat is a marked characteristic, while in ichthyosis fetalis the secretion of sweat takes place (Thibièrge). The diagnosis between hereditary syphilis and ichthyosis fetalis has only to be remembered to be made. Ichthyosis sebacea is simply a temporary exaggeration of the normal physiological desquamation of the new-born, and has nothing whatever to do with ichthyosis fetalis.

Treatment.—In a case observed by Sherwell, in which the infant lived an unusually long time, it was kept soaked in olive oil.

Douglass W. Montgomery.

Icterus.—See *Jaundice*.

Idaho Hot Springs.—Clear Creek County, Colorado.

Post-office.—Idaho Hot Springs. Hotel.

Access.—Via Colorado and Southern Railroad, the route lying through the famous Clear Creek Canyon; and by a new automobile road, a link in the coast-to-coast Automobile Highway, running through Denver's Mountain Parks and over Genesee Mountain at a maximum grade of 5 per cent. into Idaho Springs at an altitude of 7,550 feet. Idaho Springs is thirty-seven miles distant from Denver and is only fourteen miles from the crest of the Continental Divide. This beautiful mountain town is protected from inclement winds by a rampart of mountains to the north. The location is exceedingly picturesque, and the climate of a wholesome and salubrious character. Invigorating mountain breezes prevail throughout the summer. The facilities for bathing form a special attraction at these springs. Three immense swimming pools have been constructed, besides numerous private baths, the water ranging in temperature from 85° to 118° F. A natural tunnel furnishes excellent conveniences for a ready-made vapor bath, and is largely resorted to. The following analysis of the Idaho Hot Springs water has been made by the U. S. Geological Survey:

One pint contains.

Solids.	Grains.
Sodium carbonate	3.85
Magnesium carbonate	0.36
Ferrous carbonate	0.52
Calcium carbonate	1.19
Sodium chloride	0.52
Magnesium chloride	Trace
Calcium chloride	Trace
Sodium sulphate	3.67
Magnesium sulphate	2.34
Calcium sulphate	0.43
Sodium silicate	0.51
Total	13.39

Temperature 118°

Radioactivity.

Reported by Prof. G. W. Miller, State School of Mines, Golden, Colorado:

Radium emanations of Idaho Springs Water	25.11	Mache units
Radium emanations of gas from same water	1093.5	Mache units
Thorium emanations of these thermal waters	100.0	Mache units

These strongly radioactive waters of Idaho Springs issue forth about 18,000 feet distant from the pitchblende (radium-bearing rock) deposits of Quartz Hill, Gilpin County, the largest yet developed in the world. In comparison it may be said that the radioactive springs of Carlsbad, Bohemia, are twenty miles distant from the mines of St. Joachimsthal.

Within five minutes' walk of the Hot Springs there is a cold spring of sparkling, effervescent water, excellent for drinking purposes. A good carriage road leads to the summit of Bellevue Mountain, less than three miles distant, which it is said to afford the most majestic mountain view in Colorado.

The waters are useful in the treatment of rheumatism, disorders of the stomach and kidneys, and kindred ills.

The hotel is open throughout the year.

EMMA E. WALKER.

Identity, Disorders of Personal—The term "personal identity" is really tautological. The only true identity is a *personal* identity and the identity we ascribe to things is but a prototype of one's self—a projection of our own unity into things. In one sense the conception of personal indentity is axiomatic in that the conception comprised in the phrase is a *sine qua non* of all discussion or postulates. The essence of identity is unity and the origin of unity lies in that consciousness of self which makes experience possible and which must be accepted without question and as fundamental to thought in general.

A definition of identity is impossible because within the conception is to be found a basic psychic element which must be looked upon as axiomatic and inexplicable. There will always be men who appeal to external evidence to establish their own reality and identity. They are like the little old woman who, having fallen asleep on the king's highway, lost her identity through the trick of the peddler Stout, who cut off her petticoat at the knees roundabout. Quoth she

> "But if it be I, as I hope it be,
> I've a little dog at home, and he'll know me:
> If it be I, he'll wag his little tail,
> And if it be not I, he'll loudly bark and wail."
>
> Home went the little woman, all in the dark.
> Up got the little dog, and he began to bark,
> He began to bark, she began to cry,
> "Lauk-a-mercy on me, this is none of I!"

The agnosticism which allows one to give reality to things other than self while doubting one's own existence is but a farcical anachronism undeserving of serious consideration. Certain facts must be accepted without question in any branch of science. We may differ in our conclusions and deductions but certain unexplained data must be admitted without question or explanation. In circles where there is a tacit agreement as to fundamental data there is legitimate ground for discussion. Where this is wanting there asserts itself a divergence of opinion which separates the various offshoots of thought into distinct groups or sects. All eschew dogmatism as a disgraceful surrender of reason and yet no one is able to give expression to the simplest thought without proclaiming to the world a fundamental dogmatism which no one ridicules and the validity of which no one questions. Here is common ground for every man, be he civilized or savage. This fundamental axiom asserted dogmatically and accepted uncritically is the simple dictum "I." If the mere brevity of such a statement seems to abrogate its truth it may give mental repose to enlarge it by way of exemplification to "I am." If still unsatisfied with such sarcastic brevity tautology may fool us into believing that we have exemplified still further by saying "I am I" but in reality when we say "I" we have said all that can be found in "I am," "I am that I am" or "I am the same I that was and hope to be." For assumption of this one common starting point no apology is needed. Some ultra-scientific friend may wish to show his breadth of mind by manifesting a readiness to subject even this ultimate experience to question by expressing a doubt as to his own existence but he gets no sympathy even from himself.

What, then, is this core of reality which is found in every system of thought? Is personality a fixed unit or quantum asserting and preserving its aloofness through all the ramifications and undulations of mental struggle and psychic resistance? Does it pass unscathed through the kaleidoscopic modifications of experience to emerge later in full adult life with the same simplicity which marked its début at the very incipiency of infantile self-consciousness? The fact that we carry ourselves along is the only ground for any intellectuality. That there is no stagnant pool of consciousness persisting as a nucleus to experience is verified by every new experience encountered. The conscious content changes decidedly with the advent of any new element and in change and shifting is the very essence of personality—kaleidoscopic in its variations of detail and yet continuous in that not all details change during the shifting of the center of equilibrium. In fact the intensity of consciousness depends largely upon the variety of associations through which the current of thought can be identified. The richness of personality and the acuteness of personal identity are in direct ratio to the variety of associations that can be grouped about or called up under the inclusive term "I". For example, that picture represents the acme of art in which the multitudinous details serve only to direct the attention to a central thought or conception. Without the details the central conception of the whole would lack in intensity though the details as such may not receive conscious attention. The same is manifest in an analysis of the field of vision. The eye is so focused that the object of our attention falls upon the macula lutea but every object in the field of vision modifies our conception of the central object upon which attention is riveted. Let some object in the periphery assume undue prominence by shifting its position and the whole relation of things is changed. The macula lutea is immediately thrown upon it and with the change consciousness undergoes a decided modification. However, in the change enough familiar elements persist to carry us along, as it were, enriched by the addition of a new association group to our past experience. By such a process the core of personality—with due apology for such a simile—becomes intensified while the elemental details as causative agents in the process recede into relative oblivion. Could one imagine a change of scene so abrupt as to obliterate all past associations then the process of self-building would begin anew. It is extremely doubtful whether any such psychic trauma ever occurs as to obliterate personal identity *in toto*. However, certain varying degrees of modification of self do occur by this process causing the so-called disorders of personal identity.

Normal psychic life might be defined as the harmonious unification of all associated ideas into a focal complete conscious content in which all the experiences are represented proportionately to their normal intensity. Disturb this unified conscious content in any way and the so-called disorders of personal identity present themselves. However, all such disorders have a common origin and the dissociations of personality are only relative and consequently all disorders of personal identity are apparent rather than real. Analysis of the various forms of disorder will always reveal some association connecting the artificial offshoot with the mother-stem of that unitary conscious content called "self." If this were not so correction of such disorders would be an utter impossibility. Without some association connecting the segregated

personality it would be as impossible to reunite a dissociated personality with the mother stem as it would be to transfer the experience of one individual to another individual. The experiences of one individual never fuse with or become a component element of the conscious content of another individual. In other words it would be as impossible to conceive of or correct a dissociated personality without some existing association to unite it to the mother-stem as it would be to conceive of Mr. A being Mr. B or of the former being fused with the latter. We may get our own experiences confused or apparently displaced but we never feel another man's pain nor claim his experiences as ours. True, in certain disorders of personal identity the individual (*i.e.* indivisible) may think and claim he is some one else but in so doing he merely objectifies his own conscious content and embodies it in the imaginary individual other than himself. The man who lays claim to being the Christ does not in any sense surrender his own identity but merely by an acute imaginary process he frames his own inner experiences in the individuality of Christ as he conceives him to be. Every step in such a process instead of nullifying self or selfhood really emphasizes it by the double process of realization of identity and the objectification of the same into some objective setting which is again a fabrication of the very personality which is supposed to be obliterated for the time being. This is exactly what we do when we allow so-called inanimate things to irritate us. They are always conceived as resisting us. We transfer our own emotions to them and grant them an existence comparable to our own.

This same process of objectifying one's own experiences so that they can be analyzed and examined accounts for those peculiar ruptures in personality which occur when an individual gives himself good-bye as he leaves the room. We call such a man insane because he fails to unify his experiences into a harmonious conscious content. In one sense the man has not only realized his identity but emphasizes the process by objectifying his unified experience and sees himself not as others see him but as he sees himself. In no sense has he made two of himself. Most men accept their own existence without question or demand for explanation. Others analyze their own experiences, pick themselves to pieces, as it were, and no less astute an individual than Kant was fooled into the mental gymnastics of juggling abstractions as though they were concrete objective realities and his celebrated antinomies were the result. Neither phase of them has existence except in the abstract and yet the conflict between the two is so endowed with vitality that you are fooled into an admission of the reality of both. Just so with the insane man who bids himself good-bye. By a long process of introspection his own conception of self gradually takes on a vividness of depiction which grants it an objectivity all its own and the step of setting this intellectual "Frankenstein" over against himself really endows it with an individuality comparable to the unity and individuality we give things or persons other than ourselves. In the final analysis things other than self are but the objectification of our own experiences regarding the stimuli which we learn to interpret as objective things and where this intellectual process runs riot to a sufficient degree to allow us to objectify our own abstraction of the unity we know ourselves to be, the dissociation of self is complete and our own personal identity becomes duplicated or segregated.

The very opposite of this mental process is to be found in the melancholiac who so centralizes his thoughts that the universe invaginates itself within his own consciousness of self until there is but little else than his own meditations. By the same process —most intellectual to be sure but nevertheless ultra-egoistic in its outcome—the so-called phenomenalist is able to reason all objective data out of existence and reduces all existence to the narrow sphere of his own consciousness. However, this intellectual feat is always unconvincing and revolting; such solipsism always explodes as soon as an attempt is made to apply the principle in the world of experience and the lonely solipsist, tiring of himself, emerges from his shell to seek companionship in the resistance he experiences in this stubborn reaction of something other than himself. By this process his own personal identity rehabilitates itself with renewed richness of content begotten of fresh associations.

Such modifications of personal identity emphasize the astonishing complexity of the psychological entity we call mind. Instead of lighting upon a stagnant unity in our attempts to conceive of personal identity we are confronted with a complex shifting continuum so capable of variation that all phases of selfconsciousness thrust themselves upon us from the hysteric dominated by a fixed idea to the abrupt dissociation of consciousness to be found in the complicated cases of so-called multiple personality. All such phases are dependent upon the one principle that our present conscious content is dependent upon the multiplicity of its associations for its depth or richness of content. Normal consciousness finds all experiences grouping themselves about a common center and each fact falls in normal relation to its fellow thus making of the whole a continuum of experience in which complete change of the field of experience is impossible. However, let two or more central phenomena segregate and group about themselves separate sets of experience, with separate associations peculiar to each, and there occurs at once those perplexing dissociations of personality which apparently destroy the feeling of personal identity so commonly called "self." It can be readily seen that the variations to be obtained by such a process are almost infinite.

Lotze in "Mikrokosmus" third edition, Leipzig, 1878, vol. ii., p. 210, says with true insight: "Everywhere when we place a foreign body in connection with the surface of our body (for not the hand alone develops this peculiarity), the consciousness of our personal identity is in a certain sense transmitted into the ends and outer surface of this foreign body, and there arise feelings, partly of an enlargement of our personal ego, partly of a change in form and in extent of movement, now become possible to us, but naturally foreign to our organs, and partly of an unaccustomed tension, firmness or security of our carriage." If such extension of personal identity is made possible by a widening of our scope of experience is not the converse of this readily conceivable? By a narrowing of our conscious content through concentration of the mind on a limited scope of experience many experiences once vividly conscious fall outside the threshold of the conscious into the so-called subconscious. Should these latter experiences become of sufficient cumulative force to predominate there is no reason why they should not group themselves about some appropriate nucleus and strut upon the stage of consciousness to the exclusion of the former nucleus of self. This may occur to such an extent as to take on the attitude of a secondary personality, each personality being the subconscious to the other depending upon existing associations of the moment. Thus experiences are often recalled not as isolated experiences in a series tabulated chronologically but as groups and where the groups are selfsufficient you have engendered a secondary personality meager or rich in proportion to the number of associations included in the group. This underlying principle of the dissociation of consciousness will account for all the disorders of personal identity.

It is impossible in the scope of this discussion to apply this general principle to all the various disorders of personal identity. The variations or modifications are unlimited. For convenience we speak of certain prominent forms under distinct names but

the fact must not be lost sight of that such names do not signify a definite disease entity but rather give a convenient grouping for certain kindred modifications of personal identity. Take, for example, the simple form of hysteria in which the patient is in the throes or a hysterical paroxysm. One idea has apparently occupied the field of consciousness to the exclusion of all else even to the point of subsequent complete(?) amnesia for all that occurred during the paroxysm. However, he who allows himself to be fooled into thinking that the hysterical patient knows not what is going on and hears nothing of what is said during her apparent unconsciousness will be surprised years afterward at having some of those same things called out from the subconscious of his patient into full conscious reminiscence by an appropriate association. Every experience which falls into the subconscious "has a string tied to it." Pull that string and you will get the experience.

As further illustration of the same principle certain cases of multiple personality frequently relate certain dreams they have had when investigation discloses the fact that these "dreams" are not dreams but real experiences in a second personality. Furthermore one personality will at times have hazy impressions of experiences in another personality thus showing the essential intimacy between the two.

Multiple personality is strictly speaking a misnomer. For example, the case reported by me in the *Medical Record*, August 9 and 30, 1902, apparently had four different personalities X1, X2, X3, and X4, no one of which knew the experiences of the other three. However, after fusion of X1, X2, X3, and X4 into a unitary personality the resulting state X5 (X1234) knew nothing whatever of X1, X2, X3, or X4. The feeling of personal identity was complete in each and when X5 was confronted with the fact that at various times the experiences of X1, X2, X3, and X4 were unknown to him it seemed a huge joke to him and his only answer was "Yes I did I always knew those things." Only as he would recall the peculiar experiences through which he had passed could he convince himself that at certain times "he was not himself," contradictory though that conception may seem and really is. In fact the conception is untrue. The experiences of the various "selves" belong to one individual and the fusion of X1, X2, X3, and X4 into X5 was but the breaking up of the artificial and apparent dissociation of personality which left separate groups of experiences with a self sufficient personal identity of their own, limited and fragmentary though it was.

The same process occurs in hypnosis which is nothing but an artificially induced fixed idea. Take the girl who is told during the hypnotic state that on awakening she will not see Mr. A. who is one of the company present. When she awakes he is there to be sure but she does not perceive him. By the fixed idea of his absence induced while hypnotized she dissociates her experience in reference to Mr. A. from the rest of her conscious content and for the time being Mr. A. becomes an experience for a secondary personality. Should such experiences become sufficiently vivid and numerous to become riveted together by associations and to exceed those of the normal consciousness it is natural to suppose that the two states would alternate each in turn occupying the field of consciousness while the other came into abeyance and receded into the so-called subconscious. The girl who has yielded to the posthypnotic suggestion that she will not see Mr. A. must see him in order not to see him. In other words she must segregate that group of experiences in order to negate it. The negation however is but artificial and the proper association or countersuggestion immediately rehabilitates the experience known as Mr. A. In fact the negation of that group of experiences known as Mr. A. is the best proof of the fact that segregation of self is only apparent rather than real. The process is artificially induced by some association which thrusts itself into the field of experience.

Just so with the splitting up of personality giving confusion of identity. The split-off self still retains its allegiance to the parent-stem and only awaits the proper association to recall it with full vividness to its proper setting in the personal identity which is essential to complete individuality. Even in a normal selfconscious ego which has never been suspected of any disorder of personal identity the same principle is at work. All of us have apparently lost a part of ourselves in that certain experiences have dropped out of memory. Many years afterward some trivial circumstance will afford the proper association to call up afresh the old forgotten experience and after having been dormant for years it comes back with a vividness sufficiently forcible to modify the whole trend of our life. From such trivial losses of experiences from memory up to a complete dissociation of personality there are all grades of disorders of personal identity.

By way of summary it might be said that the cause of all disorders of personal identity is to be found in the tendency for experiences to group themselves into certain complexes with some crucial experience as a nucleus. The particular disorder of identity which manifests itself will naturally depend upon the scope and degree of selfsufficiency to be found in the respective groups or complexes of experiences. The cure for such conditions lies in establishing the proper associations which will reunite the various dissociated experiences or groups of experiences and give them their proper setting in the complete conscious content necessary to a full realization of individuality or personal identity.

J. Allen Gilbert.

Idiocy.—See *Mental Deficiency*.

Idiosyncrasy. This term (from ἴδιος, συν, κρᾶσις, literally, a personal or individual commingling) is applied medically to those mental or constitutional peculiarities of an individual which separate him from the majority of men. To those peculiarities which are shared by *classes* of individuals, on the other hand, the term temperament is given.

One should not include under the term idiosyncrasy qualities due to pathological conditions, as, for instance, the absence of reflexes in tabetic subjects, or sensory aberrations like color blindness, lack of smell or taste perception. But while idiosyncrasies are usually congenital, they may be, as we shall see later in the case of drug and poison addiction, acquired.

Idiosyncrasies may be overcome and it is sometimes the duty of the physician to aid in this. For instance a person who showed a morbid terror of spiders has been cured by being induced to handle a wax one which he knew to be such, until he established a toleration for a real spider. A man who always suffered from diarrhea after eating soft shelled crabs was very fond of the dish and persisted in eating them until he established a tolerance.

The most important idiosyncrasies which fall under the attention of the physician are included under (*a*) sensations, (*b*) reflexes, (*c*) infections, (*d*) foods, (*e*) drugs and poisons.

Sensations.—One of the most marked idiosyncrasies has to do with response of a given individual to pain. This is shown, for a common illustration, in the matter of vaccination. The actual insult to terminal sensory nerves in a series of patients submitting to this little operation is about the same; but while some of them will notice no hurt whatever, others will shrink and cry out in evident acute pain. Some few will faint. This varying personal factor of pain susceptibility must receive due consideration by the physician in inter-

preting the symptoms which a patient describes. Other minor discomforts, which yet, from a nosological standpoint may be important, receive very varying attention from different people. For example, the writer has observed a large scrotal tumor in an elderly bookworm who said, on his attention being called to it, that he had never noticed its presence at all. Or, again, a woman is found with a completely procident uterus to which she had never given any thought; whereas most women with a far less pronounced degree of prolapsus would have early sought medical advice. Faintness from the sight of blood or from the odor of certain flowers are familiar experiences. Tycho-Brahe is said to have fainted at sight of a fox. Henry III. of France, at that of a cat.

Auditory sensations have a peculiarly unwelcome effect on certain people. The squeak of a file, of a saw, or of a slate pencil are familiar examples. Shylock emphasizes these sensory idiosyncrasies when he says:

> "As there is no firm reason to be rendered
> Why he cannot abide a gaping pig,
> Why he, a harmless, necessary cat,
> Why he, a swollen bag-pipe...
> So can I give no reason, nor I will not
> More than a lodged hate and a certain loathing."

One of the characters of antiquity is recorded to have fainted at the sound of a flute. Instances of the sort are too numerous to be multiplied.

Reflexes.—These are perhaps more important medically than the class just considered.

Sea-sickness deserves first mention here, from its wide prevalence. In fact it is perhaps the absence of this reflex susceptibility that consitutes the idiosyncrasy. Certainly there is no way of foretelling which individuals will prove able to resist it. Freedom from it is to some extent cultivable, though it is well know that some sea captains and naval officers even lose what they have gained in that direction after a short residence ashore.

Hay fever doubtless belongs in this category, for while a pathological lesion exists in a certain proportion of cases, a reflex idiosyncrasy to certain irritants is also a factor. Whatever this irritant may be, it is doubtless similar in its action to ipecac upon another sort of idiosyncrasy. The writer knows a druggist who is so susceptible to the reflex irritation of this drug that he not only cannot dispense it himself, but is obliged to leave his store when any of his assistants is doing so.

Asthma probably owes a part at least of its etiology to a similar reflex idiosyncrasy. For while we have a determining cause in some pathological state of the respiratory tract, and an exciting cause in an acute inflammation of the bronchi, or elsewhere, we must assume in asthmatics a predisposing cause in a peculiar reflex irritability; for not all persons possessing the first two conditions have asthma. The odor or emanations of the horse may be the excitant of a severe attack of asthma.

Another reflex idiosyncrasy is that which enables the rigger and the steeple-climber to ascend to high places without giddiness or fear of falling. The production of sleep, occasionally deep and prolonged, from the hearing of music, is another instance.

It is a failure of natural reflex response to cold baths and cold affusions which explains the idiosyncrasy noted in some people at water-cure establishments. On the other hand, those untoward results of baths which include skin eruptions, eczema, furunculosis, etc., are, in so far as they are not due to uncleanly methods, to be classed among cases of individual failure of the protective apparatus to overcome bacterial invaders. Hence we have idiosyncrasy.

Infections.—The present article does not touch upon the subject of *immunity* (which see). But there is in some persons a lack of susceptibility to various diseases which can be ascribed only to idiosyncrasy. This is well illustrated by vaccinia, there being a very few persons upon whom vaccination cannot be made to "take" no matter how often repeated. Some families of children escape in epidemics of the exanthemata, while others have these diseases several times, seeming to be unable to acquire the usual immunity from one attack. The universal exposure to the tubercle bacillus would indicate that the varying resistance of different individuals was largely a matter of idiosyncrasy. The so-called "negative phase" shown by the opsonic index, while it may be produced by an unduly large injection of the specific vaccine, is found to be present before vaccination in persons showing a special susceptibility to the disease, *e.g.* acne, furunculosis, tuberculosis.

On the other hand, a special susceptibility to the effect of certain drugs and toxins arises in some animals, occasionally persisting a long time after the exhibition of the drug or poison which has caused it. This increased sensitization is called *anaphylaxis* (which see). It is of special importance in animals which have once received serum from another animal and which may remain for a long time oversensitized. Thus, a person who has received several injections of antitoxin or other serum, if after a considerable interval he be given another injection, may exhibit symptoms of anaphylactic shock.

Foods.—There are many instances of idiosyncrasy as regards special articles of diet. One person, for instance, not only cannot eat cheese without violent gastrointestinal irritation but cannot eat comfortably at a table where it is served. A special form in which these food idiosyncrasies assert themselves is in the production of urticaria from the use of certain foods. Familiar examples are fish and shell-fish, especially lobsters; also strawberries and peaches. The latter fruit with some patients will cause an intense coryza apparently like a rose-cold. Herpes and angioneurotic edema are similarly produced. Bread, especially fermented bread, and pastry are intolerable in rare cases. The same is true of honey, which is recorded in one case, when it was supposed to be a matter of whim, to have been incorporated into a plaster and applied to the feet of the patient, without his knowledge, but with serious results. Milk is an article of diet which many persons, generally mistakenly, think they cannot take. But there are really some who undoubtedly do have an idiosyncrasy against it. Regarding this as with every other article of diet, a person should, often with medical supervision to guard against error, establish the fact of his own idiosyncrasy, and having once established it should thereafter respect it.

Drugs and Poisons.—In this field idiosyncrasy may show itself either by an unusual susceptibility to a small dose, or, on the other hand, by a lack of susceptibility to the average physiological or even toxic dose. The former of these conditions is usually congenital; the latter may be either congenital or acquired. To it is given the technical name of "tolerance."

A high degree of tolerance is usually an acquired condition. It is well known that in both man and the lower animals, increasing doses of a toxin can be given till doses are tolerated far in excess of what would be fatal without such a progressive increase in dosage. The use of the toxin of diphtheria in the preparation of antitoxin is a familiar example of this. The same tolerance is established in the case of non-bacterial poisons, as, for example, tobacco, alcohol, and arsenic. But while such tolerance may appear to be present in certain organs or systems of the body, it may be absent in others. For example, the nervous system may appear to be resisting tobacco or alcohol, while the cardiac or digestive may be in reality succumbing to its use, or *vice versa*.

Such an acquired tolerance, whether in the case of toxins or of drugs, ceases soon after the regular ad-

ministration of the poison has been stopped. The term Mithridatism was applied to a supposed immunity against poison gained by King Mithridates through the systematic use of poisons employed for that end.

The Styrian peasants have long been noted for their acquired tolerance for arsenic. One sceptical traveller is recorded to have administered seven grains of arsenious acid to an apparently healthy Styrian without ill effect. The enormous doses of morphine taken by morphinomaniacs of course suggest themselves in this connection.

A tolerance for one drug sometimes develops a tolerance for others of similar nature. To this may perhaps be ascribed the large amount of ether required to anesthetize an habitual alcoholic. The writer once saw a morphine habitué who after taking nearly a dram of morphine with suicidal purpose added to the dose over one hundred grains of chloral, to which he was not specially addicted, but the conjoined dose had no serious effect. Insensibility to large doses of sedatives, as ether, chloroform, opium, hashish, and bromides, is found in some persons not habitués of any of these drugs. Such persons are apt to be of an hysterical or emotional character. A lack of response to large doses of cathartics may be dependent on the cathartic habit or may be met with independently of it. People of warm climates are said to require exceptionally large cathartic doses.

Many persons are aware of their own drug idiosyncrasies, and may properly acquaint a strange physician with them. It is unwise to disregard such information if given by a person of intelligence. In doing so one is liable to repeat the disastrous experience of a previous attendant, and even if the experiment has no other ill-effect than the temporary discomfort of the patient, the latter is likely to feel provoked that his warning was not regarded. But of course the patient may have drug idiosyncrasies which are unknown to him. It is therefore unwise for a physician in case of untoward symptoms arising, to say off-hand that they could not possibly be due to the use of a given drug, even though in his experience such a result had never occurred.

It may be said in passing that sometimes a pathological condition of some organ, involving too slow or too rapid absorption or impaired elimination, is at the bottom of what is regarded as a congenital drug idiosyncrasy. Thus renal inadequacy has been found in some persons who could not take iodine.

Childhood appears to present some special features with regard to drug susceptibility. Especially opium should be used very cautiously at this period. There is a common belief, on the other hand, that arsenic and belladonna are especially well borne by children. I think it very doubtful if this be true of the latter. Jacobi thinks children tolerate relatively large doses of quinine, digitalis, potassium iodide, and mercury.

It remains to mention a few specific drugs and poisons in regard to which marked individual idiosyncrasy is most often met.

Ivy Poison.—Here all degrees of susceptibility are met, from perfect immunity to the most intense dermatitis following the slightest contact.

Alcohol.—Here we find not only quantitative but qualitative idiosyncrasies. One man can drink down all his fellows, while the others with an equal quantity of liquor may show either amativeness, quarrelsomeness, hilarity, or gloom.

Quinine is a drug which occasionally produces ill effects in a dose much smaller than ordinarily given. Such effects are tinnitus, deafness, blindness, and erythema. The writer has seen an intense universal dermatitis follow its use, and has known a clergyman in whom a dose of two grains invariably produced a marked erythema of the scrotum. Fever and abortion have both been reported to follow the use of quinine.

Salicylic acid will cause at times an intense delirium. I have seen it simulate an acute mania and last nearly a fortnight.

Mercury finds some serious personal idiosyncrasies. One grain of blue mass has caused alarming symptoms.

Belladonna also, as is well known, causes delirium in certain patients. Serious results from the instillation of atropine solution into the eye in an amount ordinarily properly safe have been met with in unusually susceptible persons and have been followed by legal consequences.

Opium has caused vomiting, wakefulness, convulsions, and delirium. Doubtless there are some persons who should never take the drug. In the first use of the hypodermic syringe upon strangers a considerable conservatism is wise.

Potassium Iodide.—Perhaps no drug reveals more of personal idiosyncrasy than this. Two to five grains often cause coryza. Four ten-grain doses have produced an edema of the glottis severe enough to require tracheotomy. Fifteen grains a day will often cause a good deal of acne. But, curiously, patients who cannot take the small doses often can take the large ones, and the massive doses of four to six drams three times a day are generally well borne. One cannot insist too firmly that the tolerance for this drug is *not* a diagnostic criterion of syphilis.

CHARLES F. WITHINGTON.

Ignatia.—SAINT IGNATIUS' BEAN. The seed of *Strychnos ignatia* Lindl. (fam. *Loganiaceæ*). This is a large, half-climbing shrub, with very long, slender branches, and rather large, oval, pointed, three-nerved leaves. The flowers resemble those of *S. nux vomica*, and the fruit is a very large (10 to 20 cm.), solid, many-seeded, hard berry. The plant grows in the Philippine Islands, and has been introduced into Cochin-China. The fruit appears to be not uncommon in some Asiatic markets. The seed has been known to Europeans since 1699 (Flückiger).

Saint Ignatius' Beans are hard, oblong, but irregularly faceted seeds, 2 or 3 cm. in length, of a dull yellowish-gray or blackish color, and corneous texture; they are normally covered with short, coarse, appressed, glistening hairs, but these are usually rubbed off before they reach this country. The seed consists mostly of perisperm, but contains an oblong embryo, 6 or 8 mm. in length, in a cavity near the center. The seeds have but little odor, and a very bitter taste.

COMPOSITION.—*Strychnine*, to the extent of from one to one and a half per cent.; *brucine* from one-half to three-fourths per cent.; considerable albuminoid matters; no starch. These seeds, from chemical, structural, and physiological points of view, are qualitatively so exactly duplicates of nux vomica that the reader is referred to that article for further information. Because it was supposed to be more uniform in its alkaloidal percentage, and in the relative percentages of strychnine and brucine, this drug was made official in 1880, but it was found impossible to induce physicians to substitute it for the familiar nux vomica, and it was dropped at the 1890 revision. An abstract, of fifty-per-cent. strength, dose gr. i.–v. (0.06 to 0.3) and a tincture of the same strength and dose as that of nux vomica, were supplied.

HENRY H. RUSBY.

Ileus.—See *Intestinal Obstruction*.

Immigrants, Medical Examination of.—The medical aspects of immigration came up for consideration as early as 1824, when New York State, owing to the large number of aliens arriving in a diseased condition, attempted to levy a head tax on all foreign passengers who disembarked at its principal port. This money was to be used to support an immigrant

hospital. It was subsequently declared that the act was unconstitutional on the ground that the power to regulate commerce with foreign nations was vested in Congress and not in any particular State.

Until the first general act of 1882, the individual States dealt with the problem of restricting the entry of diseased aliens as best they could. Naturally efforts in this direction must have been largely fruitless, because of the ease with which entry could be effected from one State to the other.

When the Federal Government finally took supervision of the whole question in 1882, the medical phases of the subject assumed greater importance. By a State act in 1847 New York had attempted to regulate or prohibit the entry of certain classes of diseased aliens. Congress now added to the classes already excluded those who were idiots or lunatics, and persons unable to care for themselves who were liable to become public charges. The next general immigration act was in 1891, and still further increased the number of medical reasons for denying entrance by the exclusion of those persons who were certified by the examining surgeons as suffering from a loathsome or dangerous contagious disease. It was not until 1903, however, that there was a full recognition of the importance of the medical aspects of the question. The immigration law of that year not only provided for the exclusion of persons suffering from a loathsome or dangerous contagious disease, but it also provided that if the disease could have been detected at the time of embarcation by a competent medical examination, the person or company bringing the alien should be liable to a fine of $100.[1] The last act in 1907 added somewhat to the efficiency of the exclusions for medical reasons already in existence. It did this chiefly by adding the "feeble-minded" to the mandatory classes. Previous to 1907 only such grades of mental defectiveness were deported which were certified as imbecile or idiot.

In order to carry out the provisions of the law the physically and mentally defective aliens are divided into three general classes (A, B, and C)[2] as follows:

A. Aliens whose exclusion is mandatory under the law.

1. Idiots, imbeciles, the feeble-minded, insane persons, epileptics, and persons afflicted with tuberculosis.
2. Persons afflicted with a *loathsome* contagious disease; for example, favus, ringworm of the scalp, sycosis barbæ, actinomycosis, blastomycosis, frambesia, leprosy, and venereal diseases.
3. Persons afflicted with a *dangerous* contagious disease; for example, trachoma, filariasis, uncinariasis, amebic infection, endemic hematuria.

B. Diseases or defects that, in the opinion of the medical examiner, affect the ability of the alien to earn a living, or in the case of children, which will in the future so affect such ability. These diseases and defects are not mandatory under the law, but aliens who are thus certified must appear before a board of special inquiry which is composed of three immigration inspectors (not medical men) who decide on the aliens' eligibility to land. This board hears all the evidence in the case and regards the certificate of disease or defect as either contributory or conclusive evidence justifying exclusion, or else disregards it altogether and admits the alien according to the merits of the individual case (*vide infra*).

C. Diseases or defective conditions which are so slight that they do not in the opinion of the medical examiner affect the ability of the alien to earn a living. These cases may be admitted by individual immigration inspectors without being compelled to appear before a board of special inquiry.

The medical examination of all aliens and their certification when found defective under one of the above mentioned headings is undertaken by medical officers of the United States Public Health Service. There are, in round numbers fifty ports or places of entry in the United States. Besides the large ports of the sea coasts, the Canadian border, and the Mexican border are also guarded by the United States Immigration Service. Medical officers are placed at principal border points in order to facilitate the work of inspection.

The Immigration Service proper is under the control of the Department of Labor, but the medical examination, being conducted by the Public Health Service, falls under the jurisdiction of the Treasury Department. At first thought this would seem like an awkward division of authority. In practice, however, such is not the case, because the medical examination is in no sense of the word executive. The medical officers act in an advisory capacity to the Immigration Service. They establish diagnoses, and certify to the physical and mental condition of the immigrant. They have nothing whatever to do with the enforcement of the law or the deportation of the alien. The only jurisdiction which the Department of Labor exercises over the medical examination is that the Commissioner of Immigration fixes the times and places of such examination. The manner in which they shall be conducted and the rules governing the conduct and personnel of the medical force are left entirely in the hands of the Surgeon General of the United States Public Health Service. Under existing conditions the medical examiners can have no possible interest in the final disposition of the alien. They are simply a staff of experts who render their opinion without fear or favor.

Besides the examination conducted at the ports of entry into this country, there are medical officers attached to the consulates abroad who have from time to time conducted examination of persons intending to emigrate to the United States. Under the present law such examinations cannot be final. They are made only with the view of giving expert advice as to the aliens' eligibility to land from the physical or mental standpoint. Whether the steamship companies follow this advice is entirely optional. If the alien desires to come any how and the steamship company cares to take the chance of exclusion at the port of entry, there is nothing to prevent such action. As a matter of fact the advice is usually taken, and in Naples where this plan is in force at the present time, it has been found to facilitate greatly the landing of healthy immigrants, and to prevent many deportations naturally following among those who come from ports where no such preliminary inspection is conducted.

At Canadian ports there is also an examination of immigrants whose final destination is the United States. This is also conducted by our Immigration Service with medical officers of the Public Health Service acting in an advisory capacity in the same manner as at the places of entry within our own territority. We reciprocate with Canada in this matter, and at our principal ports of entry, Canadian immigration officials are stationed who conduct an examination of aliens whose final destination is that country.

In the event of an alien arriving with a quarantinable disease he is placed in a hospital and isolated according to the law governing such conditions at that particular port. For example, in New York the quarantine is undertaken by the State of New York itself, and the health officer of the port boards all incoming vessels and removes, regardless of nationality, all persons suffering from infectious diseases whom he may see fit so to remove. These persons are isolated in the State's hospital provided for the purpose until recovery and such time as danger from infection is over. After this period has elapsed he turns over to the United States immigration officials all *aliens* whom he has thus detained, and the medical examination is then undertaken in precisely the same manner as in

the case of those who have not been quarantined. Thus it will be seen that the medical examination for the enforcement of quarantine law, and that for the enforcement of the immigration law are entirely separate and distinct functions. The one seeks primarily to protect the community from epidemics of disease which threaten at the moment. The other seeks to protect the country from an influx of physical and mental defects whose deleterious influence will be lasting.

For ten years past the annual immigration into the United States has never been less than 700,000.[3] In six of these ten years it has been over one million. Broadly speaking three-fourths of all immigrants come in the steerage. The remaining come in the various cabins and by rail over the borders.

The method of medical inspection will vary somewhat according to whether it is conducted on board ships, on incoming immigrant trains, or at an immigrant station where special facilities are provided for the purpose. However the general principles are the same in all cases. As seventy-five per cent. of all arriving aliens come through the port of New York the method of examination as conducted at the Ellis Island station may be taken as the standard which is used at all places with such modifications as the peculiar conditions may require. At New York the steerage immigrants are brought on barges from the docks to Ellis Island. They are made to pass in single file before the medical examiners. Each line of passing immigrants is inspected by two physicians. One is placed at the angle of a right angled runway, the other at the end. The physician at the end of the runway everts the eyelids to look for trachoma, while the one at the angle of the runway looks for all mental and physical defects except trachoma. Either the physicians themselves, or attendants at their direction, make a distinctive chalk mark on the clothing of every immigrant who presents any evidence of physical or mental defect or disease. Those who have no chalk marks on their clothes are directed by attendants to the general line of travellers going toward the registry division of the station. These *unmarked* ones are not detained any further by the medical division. Those who have been marked on the line are turned aside into the special examining quarters where attendants distribute them to the particular rooms which the chalk mark on the clothes indicate. In these rooms other examiners make the detailed examination which the chalk mark calls for, and also note any other condition which may have been overlooked. Those who require further observation to determine the exact nature of their affection are either sent to the hospital or held in detention quarters in the same building according to the nature of the particular case. When the immigrant is acutely ill his examination touching eligibility to land is postponed, and he is sent to the hospital pending recovery from his acute condition. The final examination of the alien results either in his being turned over to the registry division of the station with a report that he is medically sound, or in his being delivered to them with a certificate which falls under one of the above-mentioned four classes.

It will be obvious that the detailed physical examination of all immigrants who have been turned aside from the primary inspection line with a chalk mark on their clothing, and hence fall under the close scrutiny of those who are in the examining rooms, does not present any characteristic feature aside from the difficulty in obtaining a history from any person speaking an alien tongue. In all essentials this is an ordinary physical examination and is conducted on the same general lines as in the out-patient department of any hospital. When it comes to the mental examination the case is entirely different. The strangeness of the surroundings, the fatigue and excitement of the journey, and the fear of deportation, are some of the many factors that must be overcome before any attempt is made to determine the mental status of the immigrant who is suspected to be mentally deficient or insane. The examiner having placed himself *en rapport* with the one to be examined there still remains the insurmountable handicap of difference in language. Conducting a mental examination through the medium of an interpreter can never be an entirely satisfactory procedure. When the immigrant is ignorant and illiterate the conditions are about as far removed from the ideal as possible. Another difficulty is the one of obtaining a history. The insane often have sufficient insight to know that frank conversation regarding their mental state will result in their deportation. For a similar reason the family history of insane and mentally defective aliens can seldom be obtained from friends or relatives. In the case of the suspected insane, the only method available to overcome these difficulties is that of observation in the hospital wards for such a period as may be necessary to arrive at a conclusion. In the case of those who are suspected of being mentally defective, the obstacles are partly overcome by requiring the performance of tests or puzzles which can be solved by illiterate normal individuals without the aid of language. No one system of intelligence tests yet devised is applicable to all aliens. The present plan is to combine the knowledge obtained by observation, oral examination, and the performance of a few reliable mechanical tests, and in this way come to a final conclusion concerning the mental status. Different races of people appear to have different standards of normal mentality. The Public Health Service is at present conducting an intensive research to determine what these standards may be. In the near future it is hoped that these investigations may result in a standardized system which will allow of more rapid and thorough examination than is at present possible. Notwithstanding the necessarily slow and tedious methods of diagnosis in vogue, the number of certifications for mental defects has rapidly increased until now it appears as one of the largest single causes for deportation.[4]

Aside from the difficulties connected with the diagnosis of mental conditions the peculiar features of the medical examination of immigrants are chiefly those of the primary inspection. Here is where special training and quickness of observation are most needed. Here also is needed the faculty to discriminate between racial characteristics and pathological conditions of mind or body. For example one must be well trained before he can quickly determine what constitutes a healthy color of the skin in a particular race. A healthy gipsy might be suspected of Addison's disease. A sound West India mulatto often has a peculiar pallor resembling that of tuberculosis, and the dilated capillaries common among the temperate mountaineer of Alpine stock are suggestive of chronic alcoholism. Moreover, certain classic signs of disease may be without special significance in the newly arrived immigrant. For instance, pulsating vessels in the neck are often caused by the increased heart action arising from fear, and if this symptom presents itself in an immigrant without signs of broken compensation or symptoms of exophthalmic goiter, it is not sufficient cause for sending him into the examining rooms. Seasickness on board often leaves bad effects for several days, and the resulting pallor and weakness are suggestive of some grave constitutional trouble. The irritation of the conjunctiva caused by certain occupations involving exposure to heat and dust, such as iron moulding, baking, and coal mining, not infrequently induces a chronic inflammation and scar formation closely simulating the appearance of an old incompletely cicatrized trachoma. The faces of muscular able-bodied Italians are often so devoid of adipose tissue and muscle that at first thought one would conclude that the whole body was equally thin and undeveloped. Likewise the mental reaction of the immigrant to the process of medical inspection must always be interpreted in

the light of a full knowledge of his racial characteristics. The stolidity and apparent indifference of the Slav would be suggestive of melancholy if presented by the South Italian or Irish immigrant. If the Englishman evinced the same signs of emotion which the Greek shows on a slight provocation, his sanity would at once be in question. It is perfectly normal for the German girl to take her medical inspection quietly, seriously, and as a matter of course, and should she see the same cause for laughter or light remark in the process as her sister from Ireland, we should at once suspect that she might not be mentally balanced.

Keeping in mind the fact that all symptoms must have their relative values interpreted in the light of a full knowledge of the peculiar conditions under which they are observed, and with due regard to the racial characteristics of those who present them, the medical inspector stands facing the line of oncoming immigrants. They approach him slowly with an interval of about ten feet between each person. As the person to be inspected approaches him, he notes almost simultaneously the gait, stature, expression of the face, skin color, and eyes. Although this is apparently done at one glance the most efficient inspectors really use some system of order in the general observation. Probably the best way is to commence with the feet, note the character of the gait, and let the eye run up the legs and body, taking in any gross pecularities of hands or legs on the way, noting last the face, eyes and scalp, and also the mental reaction of the individual to the unusual scrutiny to which he is being subjected. By this time the subject has arrived face to face with the examiner who has already formed a first impression of his general condition. He now places his hand on the forehead and by word or gesture indicates that the mouth should be opened. The sense of touch gives an idea of the presence or absence of fever. At the same time the sense of sight takes in the condition of the gums, teeth and mouth. The acuity of hearing and the general mentality are judged by the degree of readiness in responding to the request to open the mouth. The sense of smell comes to the aid of the examiner simultaneously with those of sight, touch, and hearing, and may indicate to him favus, uremia, ozena, foul ear discharges, and ulcers or abcesses concealed by the clothing. By passing the hand from the forehead over the shoulder and down the arm, an idea of the muscular development is obtained. Inspection of the hand should indicate the presence or absence of chronic wasting disease—clubbed fingers suggesting especially tuberculosis and heart disease. The hands of the gouty diathesis, of arthritis deformans, myxedema, cretinism, acromegaly, achondroplasia, and Mongolian idiocy may be quickly recognized and mentally noted. If the hand is cold and clammy it will be due to some circulatory disturbance, and experience will serve almost instantly to relegate this disturbance to its proper category of fright, nervousness, exposure to cold and dampness, or possibly organic heart disease. While this cursory inspection is going on a few questions directed to the immigrant in his own language, serve very materially in determining whether he shall be allowed to pass on or be held for further detailed examination. It is best to follow some regular system in the questioning. In practice it is found that questions involving knowledge of name, place, nationality, and simple numbers are best for obtaining an idea of the general mental status of the immigrant. At the same time that the character of the answers give an idea of the intelligence, the nature and quality of the voice may give a clue to abnormal physical conditions. Thus a highly pitched feminine voice may increase the suspicion of arrested sexual development which has been aroused by noting the absence of beard and the peculiar wrinkles on the upper lip and at the angles of the mouth. A tremulous voice may add weight to the theory of chronic alcoholism which has been suggested by the capillary stasis of the nose and cheek, and fine tremors of the fingers. Hoarseness further confirms a suspicion of tuberculosis, while a scanning speech demands a special examination for multiple sclerosis or paralysis agitans. Perhaps before the speech or the facial expression had been noted suspicion had already been turned in this direction by the peculiarity of the gait.

The powers of observation thus rapidly and systematically extended to embrace the whole body and its outwardly manifested functions, enable the examiner to determine in a very few moments whether he shall let the immigrant pass by or have him detained for further detailed examination. Before one hastily assumes that little can be accomplished by casual inspection, he should remember the possibilities which lie in observation of the gait alone. As illustrating how great these possibilities are, it might be noted that all the following conditions produce a suggestive manner of locomotion, viz., dislocation of the hips, hip-joint disease, rheumatism, artifical legs, various paralytic affections, ankylosis of the hips, ankles, and knees, locomotor ataxia, paresis, paranoia, idiocy, imbecility, flat-foot, club-foot, acute local infections, phlebitis, epididymitis, scrotal tumors, neuritis, rectal inflammations, gonorrhea, rickets, muscular dystrophies, corns, bunions, cerebral and cerebellar tumors, the acute intoxications of alcohol and other drugs, and acute abdominal pains from any cause.

When it is remembered that not only the gait, but every movement of the body has its own peculiar meaning, and that careful practice enables one quickly to interpret the thousand and one variations from the normal, it will be seen that the art of diagnosis by inspection is the greatest single asset of the successful medical examiner of immigrants.[5]

That this sifting-out process which is thus quickly effected as the line of immigrants files by has in reality a great deal of value is shown by the following figures. The report of the Surgeon General for 1909 shows that out of the total number of immigrants entering the United States during that year, 1.5 per cent. were certified by the examining surgeon for defects which either made their deportation mandatory or else required the submission of satisfactory proofs that they would not become public charges. This percentage of certifications to total number inspected has been gradually increasing. This is graphically illustrated in Fig. 3371,* where it will be seen that at Ellis Island the increase has been more than twofold during the past decade.[6]

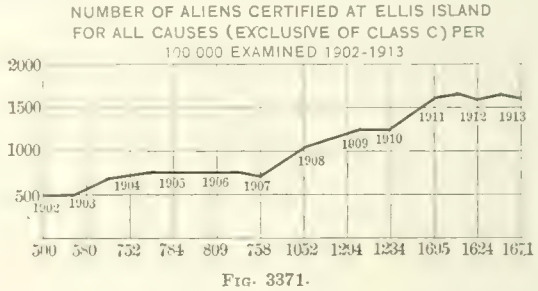


Fig. 3371.

Although the actual admission or deportation of certified aliens in no way concerns the medical examiners, it is nevertheless a matter of interest to know the disposal of these cases, for it is in this way alone that one can arrive at an intelligent opinion concerning the practical value of the whole procedure. When one carefully studies the law and the restrictions which it places upon the landing of immigrants, he is im-

*The compilation of the figures on which this chart is based was made by Dr. Thomas W. Salmon, U. S. Public Health Service.

pressed with the fact that the medical reasons for deportation take the most prominent place. In fact one may say in a general way that if an alien over sixteen years old is not a criminal, a contract laborer, a pauper, a polygamist, or an anarchist, he will almost

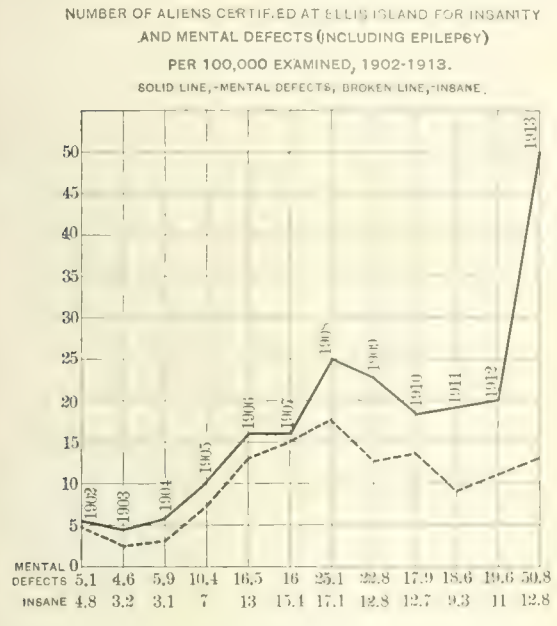

NUMBER OF ALIENS CERTIFIED AT ELLIS ISLAND FOR INSANITY AND MENTAL DEFECTS (INCLUDING EPILEPSY) PER 100,000 EXAMINED, 1902-1913.
SOLID LINE,-MENTAL DEFECTS, BROKEN LINE,-INSANE.
1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913
MENTAL DEFECTS 5.1 4.6 5.9 10.4 16.5 16 25.1 22.8 17.9 18.6 19.6 50.8
INSANE 4.8 3.2 3.1 7 13 15.4 17.1 12.8 12.7 9.3 11 12.8

Fig. 3372.

certainly be allowed to land if he is able to pass the medical inspection. The prominence of medical reasons as cause for deportation is illustrated in Fig. 3373 where it will be seen that although non-medical reasons for deportation vary greatly from

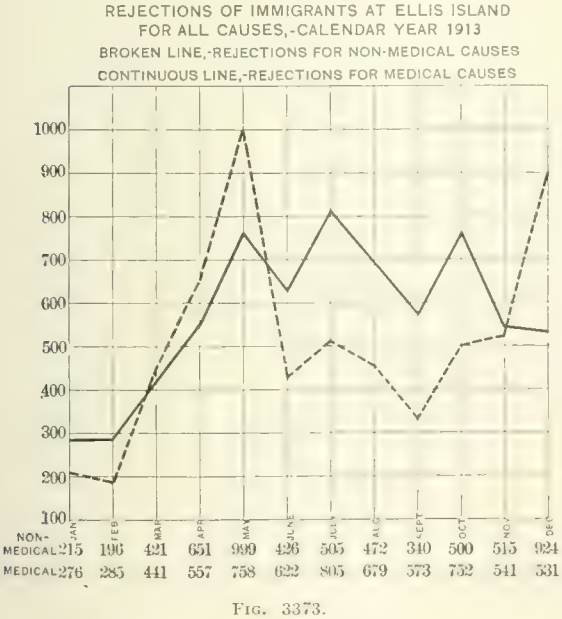

REJECTIONS OF IMMIGRANTS AT ELLIS ISLAND FOR ALL CAUSES,-CALENDAR YEAR 1913
BROKEN LINE,-REJECTIONS FOR NON-MEDICAL CAUSES
CONTINUOUS LINE,-REJECTIONS FOR MEDICAL CAUSES
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
NON-MEDICAL 215 196 421 651 999 426 505 472 340 500 515 924
MEDICAL 276 285 441 557 758 622 805 679 573 752 541 531

Fig. 3373.

month to month they do not on the whole maintain the high level of the medical.

Vast numbers of immigrants are certified by the examining physicians as having diseases or physical defects which affect ability to earn a living who are nevertheless allowed to land by the boards of special inquiry which hear all the evidence in the case. This is graphically shown in Fig. 3374.

The reason that the boards of special inquiry admit an alien with a certificate of defect affecting ability to earn a living, is not because the diagnosis of the physicians is called in question, but because they obtain information which leads them to believe that the disability in the particular case under consideration will not render the alien liable to become a public

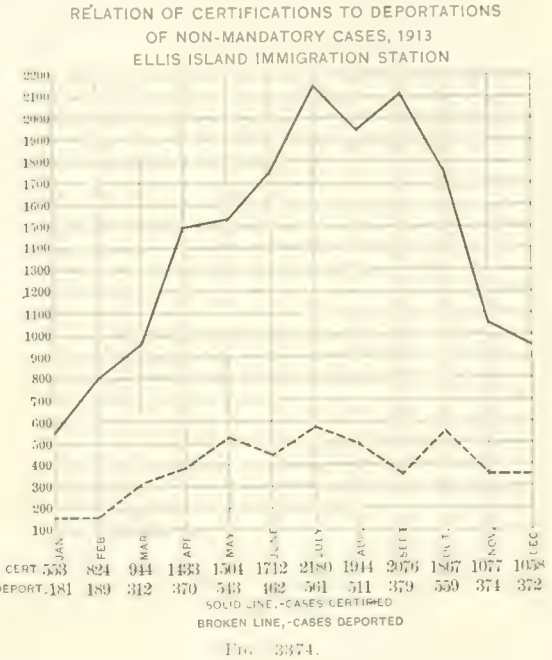

RELATION OF CERTIFICATIONS TO DEPORTATIONS OF NON-MANDATORY CASES, 1913
ELLIS ISLAND IMMIGRATION STATION
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
CERT 553 824 944 1433 1504 1712 2180 1944 2076 1867 1077 1058
DEPORT. 181 189 312 370 543 462 561 511 379 550 374 372
SOLID LINE,-CASES CERTIFIED
BROKEN LINE,-CASES DEPORTED

Fig. 3374.

charge. There are many typical illustrations of such cases. For example, a man may be certified as suffering from "arteriosclerosis which affects ability to earn a living" and be admitted by the board of special inquiry because of the sworn statement of his children that they are domiciled in the United States and promise to support their parents, giving evidence which shows that they are financially able to do so. Another may be certified as having "loss of one leg at the knee which affects ability to earn a living" and nevertheless be

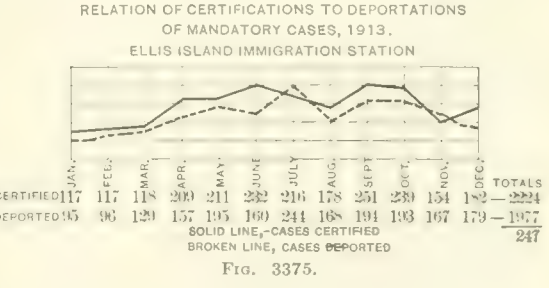

RELATION OF CERTIFICATIONS TO DEPORTATIONS OF MANDATORY CASES, 1913.
ELLIS ISLAND IMMIGRATION STATION
JAN. FEB. MAR. APR. MAY. JUNE JULY AUG. SEPT OCT. NOV. DEC.
TOTALS
CERTIFIED 117 117 118 209 211 232 216 178 251 239 154 182 — 2224
DEPORTED 95 96 129 157 195 160 244 168 194 193 167 179 — 1977
247
SOLID LINE,-CASES CERTIFIED
BROKEN LINE, CASES DEPORTED

Fig. 3375.

admitted by the board of special inquiry because it has ascertained that his occupation is such that in his particular case his ability is not affected. And so illustrations might be multiplied almost indefinitely, but these are sufficient to explain the discrepancies existing between the number of aliens certified and those deported on account of physical defect or disease which affects ability to earn a living.

Theoretically the number of deportations for mandatory causes should exactly equal the certifications.

As a matter of fact it does not approach it. The discrepancy noted (see Fig. 3375) is chiefly accounted for by the fact that the law of 1907 is so worded that aliens certified under Class A-2, but whose immediate family is domiciled here may in certain instances be temporarily landed under bond for treatment.[7] A certain percentage of these cases recover and are admitted.

The foregoing facts and figures show that the result of the medical inspection for immigrants is on the whole what the law intended it should be. Aside from the direct elimination of a large number of undesirables there is an indirect elimination which takes place through fear of the medical examination. The fear of the law and the thoroughness of the inspection are sufficient to cause all the large steamship companies to employ physicians to examine immigrants before they are allowed to embark. These physicians refuse passage to those persons whom they feel morally certain would be certified on arrival as mandatorily excludable. Their sole interest is to protect the steamship company from the expense of fines and the transportation of deported cases. Thus the law has indirectly made the steamship companies a more or less unwilling ally in the medical inspection of immigrants.

J. G. Wilson.

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Immunity.—The aspects of immunity considered in this article are those connected with the resistance of animals and man to the invasion of microorganisms and to poisoning by their products. The degree of immunity varies from a trace to absolute.

The two factors always to be considered are the microorganisms and the host. An increase in virulence of the germs or in the number brought in contact with the host may bring about infection when with those of the same virulence, but less in number or with lessened virulence and the same number no infection would occur. The host also varies. The protecting covering may be injured or removed, the bactericidal properties of the body fluids may be lessened or increased and so the degrees of immunity vary. We will now consider these conditions in detail.

Experience and observation have taught us that various races of animals and men, and various individuals among these, differ in their susceptibility to certain diseases; and, further, that as already stated the same individual is at one time more resistant to such diseases than at another. This inborn or spontaneous refractory condition is termed natural immunity, in contradistinction to that acquired during an attack of disease.

As in microorganisms we distinguish between the ability to produce poison and the power to multiply, so in animals and man we may distinguish between immunity to poison and immunity to the invasion of bacteria.

With regard to wide variations in susceptibility, certain facts have been ascertained. Thus, cold-blooded animals are generally insusceptible to infection from those bacteria which produce disease in warm-blooded animals, and *vice versa*. This is explained in a measure by the inability of the bacteria which grow at the temperature of warm-blooded animals to thrive at the temperature existing in cold-blooded animals. But differences are observed not only between warm-blooded and cold-blooded animals, but also between the several races of warm-blooded animals. The anthrax bacillus is very infectious for the mouse and guinea-pig, while the rat is not susceptible to it unless its body resistance is reduced by disease and the amount of infection is great. The inability of a microorganism to grow in the body of an animal does not indicate an insusceptibility to its poison. Differences in susceptibility are sometimes very marked among different varieties of the same race of animals, as, for instance, between different kinds of rats and pigeons to anthrax. In animals, as a whole, experiments have shown that the young of all species are on the average less resistant to infection than the older and larger ones. The only exception to this is the immunity of the very young which are born of immune mothers. This is due to the passage of immune substances from the mother to the offspring.

The difficulty experienced by many microorganisms in developing in suitable tissues of the healthy body can be to a great extent removed by any cause which lowers the general or local vitality of the tissues. Among the causes which bring about such lessened resistance of the body are hunger and starvation, bad hygienic surroundings, exhaustion from overexertion, exposure to cold, the deleterious effects of poisons, bacterial or other, acute and chronic diseases, vicious habits, drunkenness, etc. Purely local injuries, such as wounds, contusions, etc., give a point of entrance for infection, by removing protecting cells and lessening the resistance of others. Paths are opened where the bacteria may develop and produce local inflammation. Local disease processes, such as endocarditis, may also afford a weak spot for the bacteria to seize upon. The presence of foreign bodies in the tissues in like manner predisposes them to bacterial invasion. The association of different varieties of bacteria with the pathogenic strain may increase the liability to infection. Interference with free circulation of blood and retention in the body of substances which should be eliminated also tend to lessen the vitality. In these and other similar ways animals which are otherwise refractory may acquire a susceptibiltiy to the invasion of microorganisms.

Increase of Immunity by Non-specific Means.—Just as all conditions which are deleterious to the body lessen its power of resistance to bacterial invasion, so all conditions which are favorable to it increase its resistance, and thus aid in preventing and overcoming infection. The internal use of antiseptics against bacteria has not proved successful, for the reason that of all known non-specific bactericidal substances an amount sufficient to inhibit bacterial growth is found to be poisonous to the tissue cells. The efficacy of mercury in syphilis is possibly an exception to this rule. In dealing with animal parasites, and with certain moulds there are a number of notable exceptions; *e.g.* emetin in amebiasis, quinine in malaria, trypanred in trypanosomiasis, and iodides in sporotrichosis. Such substances as leucocytic extract, nuclein, and some other organic substances have some slight effect in inhibiting bacterial growth. The hastening of elimination of the bacterial poisons by free intestinal evacuation and encouragement of the functions of the skin and kidneys are also of some avail. The removal of toxic products by draining an abscess or the attenuation of the microbes by direct application of germicidal washes as in exposure to gonorrheal or syphilitic virus aids greatly in preventing the spread of infection unless such damage is done to the tissues as to reduce the resistance of the cells. The enzymes formed by certain bacteria have been found to exert

a slight bactericidal action, not only on the germs which have produced them in the body, but also on other varieties. None of these enzymes is sufficiently protective, however, to be of practical value nor equal in power to the protective substances formed in the body after infection with many microorganisms.

Specific Immunity.—The invasion of the body by almost every variety of microorganism is followed, if death does not quickly ensue, by conditions which for a variable period and to a variable degree are deleterious to the further growth of that variety. This form of immunity may develop in those not having passed through an infection. The explanation of this is as yet unknown. This more or less pronounced specific immunity may be created in various ways:

1. Through recovery from disease naturally contracted or from infection artificially produced. According to the nature of the invading microorganism this immunity may be slight, as after recovery from erysipelas or pneumonia, marked for a limited period of time, as in diphtheria and typhoid fever, or prolonged, as after scarlet fever or smallpox. The extent of this protection also varies in different persons after the same infection.

2. By inoculation with microorganisms attenuated by heat, chemicals, or other means. In this case an infection of the animal is produced, of moderate severity, as a rule, and the immunity is not quite as marked and lasting as after recovery from more serious attack; but it is, nevertheless, considerable. The inoculation of sheep with the attenuated anthrax bacillus and the use of vaccination with cow-pox in man are examples of this method.

3. By the injection of the living organisms into tissues where development will not take place, as the injection of diphtheria bacilli, typhoid bacilli or cholera spirilla into the subcutaneous tissues. Here the destruction of the bacteria with the absorption of their products causes mild chemical poisoning, with considerable resulting immunity.

4. By the injection of the dead bodies of bacteria or of the chemical products which they elaborate and discharge into the surrounding culture media during their life. This produces a less marked immunity than when the living culture is used, but the method is a safer one.

5. By the spontaneous action of the cells. Little is understood of the conditions under which antibodies develop where no infection is present. The clearest illustration of this form of immunity is in the case of those developing diphtheria antitoxin. At birth ninety per cent. of all infants have "natural" antitoxin derived passively from their mothers. At two years of age this remains in only about twenty-five per cent. The proportion immune then steadily increases until the adults show as in infants about eighty-eight per cent. immune. In some the antitoxin present amounts to over ten units per cubic centimeter.

It seems impossible for any such proportion of the people to be carriers of diphtheria bacilli. This natural antitoxin seems to be identical with that produced after infection. It is well known that many persons as they grow older develop immunity to scarlet fever and other diseases.

6. By the injection of the blood serum of animals which have previously passed through a specific disease, or have been inoculated with the microbic products. The first, probably, to think of the possibility of effecting this was Raynaud, who in 1877 showed that the injection of large quantities of serum derived from a vaccinated calf into an animal prevented its successful vaccination. The results obtained by Behring and Kitasato upon diphtheria and tetanus, where the serum neutralized the poisons rather than the direct development of the bacteria, gave a still greater impetus to these investigations.

Suitable animals after repeated infections gradually accumulate in their blood considerable amounts of these protective substances, so that very small amounts of serum inserted in another animal will inhibit the growth of the microbes or neutralize their products. Thus, 0.1 c.c. of a serum from a horse frequently infected by the pneumococcus will prevent the development in the body of a rabbit of many thousand times the fatal dose of the same strain of very virulent pneumococci, and a few times a fatal dose of less virulent ones, the actual number as well as the virulence of the bacteria affecting the protective value of the serum.

Location of protective substances. These are believed to be present in the substance of many cells to a greater or lesser extent. This is especially true of those in which antibodies have developed. As they are eliminated they pass to the lymph and then to the blood.

The protective substances pass from the blood through the walls of the capillaries and finally find their way to the lymph and back to the blood. The closed cavities of the body like the spinal canal, the pleural sac, etc., contain much less antibodies than the lymph. When the general immunity is but slight, infection may take place in the more sensitive regions or those in which the antibodies are less abundant or where a large number of organisms have gained access, and still be impossible in those tissues having more natural resistance or slighter infection.

The Nature of the Protective Defenses of the Body.—The tissues of the animal body under the normal conditions of life are unsuitable for the growth of the great majority of bacteria, and are only fairly favorable to the development of the few remaining. Indeed, only a very small number of varieties of bacteria find the conditions really satisfactory, and even these must gain a point of entrance.

In seeking for a reason for the difficulty experienced by the bacteria in growing in the tissues, we cannot expect to find it in either the lack of or concentration of the nutritive substances, in the temperature, or in the reaction; for although these conditions may be unsuitable for some bacteria they are suitable for many, and thus cannot constitute the fundamental explanation of immunity. A possible reason for the inability of the bacteria to invade living tissues may be in the fact that the nutritious material in the living cells is in a form which the bacteria cannot readily assimilate; but if this be true it does not adequately explain why the bacteria do not develop in the nutritious fluids so abundant about and in the body tissues. We are thus driven to the conclusion that the body fluids themselves contain substances which are directly deleterious to the bacteria. As to the origin of these substances, it is conceivable that they may be either regularly produced in very small amounts in the cells or that they may be produced only when the body is invaded by microorganisms. They may then remain unaltered in the fluids or be quickly eliminated. More than one of these things may actually occur.

The bactericidal effect of sera upon most bacteria is shown by the fact that when injected into the blood they begin to die at once, and this often continues until in a few hours all have died. Even when bacteria produce infection there is usually for a time a decrease in the number of bacteria living, but this is soon followed by a progressive increase. This fact can be observed not only in the blood and peritoneal cavity, but also when the bacteria are enclosed in animal or vegetable capsules, where the serum passing into them destroys the bacteria. The bacteria are killed even if they have previously grown in blood serum. Bacteria have also been injected into a

vein carefully ligated above and below, and here without coagulation the blood exerts bactericidal properties. Even spores are killed in a few days. The effect of the fresh unheated blood serum can also be watched outside of the body. Here some species of bacteria die quickly, some slowly, and some lose only a portion of their number, and here the remaining portion after a time rapidly increases. The number of bacteria introduced is of great importance, for the serum seems capable of destroying only a certain number and after that loses its bactericidal properties. Nuttall first drew attention to these facts. Buchner in 1889 showed that serum heated to 55° C. lost this destructive power and this led to a separation of the germicidal elements of the serum into different components.

Buchner made many experiments on the nature of the process. He showed that bacteria absorbed these bactericidal substances. Later, Bordet, Ehrlich, and others established that the alexin of Buchner was really a mixture of two types of substances of which one, named "immune body," "sensitizer," or "opsonin," is developed as the result of the injection of foreign cell substance, and the other, named "complement" or "alexin," is present in the blood of normal animals, and is not increased by injection. Neither one of these types of substances alone destroys bacteria, while together they destroy certain varieties. Other bacteria require the action of the complement-like ferment in the leucocytes also.

The Nature of Bacteriolytic, Hemolytic, Cytolytic Sera.—Bordet, through his own researches and those of Gruber and Durham, was able to show that the same type of reaction took place in the animal body when cells of any kind were injected. He showed, for instance, that there was a close similarity between bacteria and the cells of the blood. By immunizing an animal, species *A*, with red-blood cells of animal, species *B*, he found that the blood of *A* became hemolytic for the cells of *B*, just as if immunized with cholera spirilla it would have been bacteriolytic for cholera spirilla. Since then truths obtained from investigation with any type of cells have been applied equally to all others. This made it possible for Ehrlich, Bordet, and others to study the nature of these processes upon blood cells instead of bacteria.

Limitation of Curative Power of Serums which Act Directly against Microorganisms.—As a rule, the serum has to be given before the bacteria introduced into the body have multiplied greatly. After that period has elapsed the serum usually fails to act. This is partly because the germicidal and antitoxic substances of the serum are insufficient in amount, partly because suitable antibodies develop for only a portion of the varied types of poison produced by microorganisms and partly because the bacteria developing in the blood stream and tissues of the body develop a condition which renders them resistant to the germicidal action of the serum.

Practical Therapeutic Value of Bactericidal Sera.—The use of serums having specific protective properties has been tried practically on a large scale in man as a preventive of infection. In susceptible animals injections of some of the very virulent bacteria, as pneumococci, streptococci, meningococci, and typhoid bacilli, can be robbed of all danger if small doses of their respective serums are given before the bacteria have increased to any great extent in the body. If given later they are usually ineffective. For some bacteria, such as tubercle bacilli, no serum has been obtained of sufficient power surely to prevent infection. Through bactericidal serums, therefore, we can immunize against many infections, and even stop some just commencing; but as yet we cannot cure an infection which is already fully developed, though even here there is reason to believe that we may possibly prevent an invasion of the general system from a diseased organ, as by the pneumococcus from an infected lung in pneumonia. On the whole, the serums which simply inhibit the growth of microbes without neutralizing the toxins have not given, as observed in practice, conclusive evidence of great value in already developed disease, unless the serum can be brought in considerable concentration in contact with the infected tissues as is done by intraspinal injections in cerebrospinal meningitis. An important limitation is that bacteria apparently similar in their morphological and cultural characteristics may be quite different in their immunological qualities. This has been brought out very clearly by the work of Cole who found that the majority of pneumococci exciting pneumonia in New York belong to three distinct types each of which is distinct in its relation to immune sera. Type one is destroyed by antibodies produced in animals because of infection with type one, but not by antibodies produced by type two. He has had considerable success in treating cases caused by type one, when type one serum was used, but little or no results have been obtained in the treatment of cases due to the other types even when sera obtained from horses immunized to similar stains was employed.

Relative Development of Antitoxins and Bactericidal Substances in the Different Infections.—Although the serum of animals which have been infected with any one of many varieties of bacteria is usually both antitoxic and bactericidal, still one form of these protective substances is usually present almost alone; thus antitoxic substances are present almost exclusively in animals injected with two species of bacteria which produce powerful specific poisons—viz., the bacilli of diphtheria and tetanus. When the toxins of either of these are injected in small amounts the animals after complete recovery are able to bear a larger dose without deleterious effects. To Behring and Kitasato we owe the discovery that this protecting substance accumulates to such an extent in the blood that very small amounts of serum are sufficient to protect other animals from the effects of the true extracellular toxins.

Except the diphtheria and tetanus bacilli, a few only of the important parasitic bacteria attacking man produce these extracellular toxins in any considerable degree and thus become capable of causing the production in the body of antitoxins, and even these do it to a far less extent than those of tetanus and diphtheria. Following them are the dysentery and plague bacilli, and then the cholera spirilla, the typhoid bacilli, the gonococci, meningococci, streptococci, etc. These latter bacteria when injected excite more of the substances which inhibit bacterial growth than of those which neutralize their toxins. The bacillus of symptomatic anthrax and of botulismus and the vegetable poisons ricin, crotin, and abrin also produce specific antitoxins. So far, neither protozoa nor moulds have been shown to produce specific antitoxin, though with a few species agglutinins and other antibodies have been demonstrated.

Passive as Contrasted with Active Immunity.—After the immune serum is injected into man the immunity is highest at the time of its greatest accumulation in the blood. This point is reached instantaneously after an intravenous injection, but only after forty-eight to thirty-six hours when given subcutaneously as seen in the estimation of the antitoxin content in the blood of two goats (Fig. 3376), and then declines, being rather quickly (in several months or weeks, according as to whether or not the serum is injected into the same species of animal as the one from which it was drawn) almost entirely lost, so that repeated injections are required to maintain the immunity. This passive immunity is distinctly in contrast to the active immunity acquired after the introduction of microbes or microbic products, where the tissues of the organism, in ways to us unknown, throw out, in response to the microbal stimulus, inhibitory or antitoxic substances. Here immunity is actually lessened for one

or two days, and then is increased, and reaches its height a week or ten days after the injection, and then continues for a week or two, when it slowly declines again and is lost after several months or years.

Names Attached to Substances Producing Cytolysis.—Different investigators have applied to them different names. The one which is resistant to heat, which

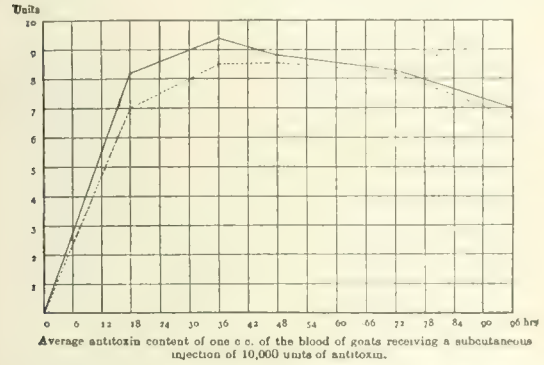

Fig. 3376.—Average Antitoxin Content of Goats Receiving a Subcutaneous Injection of 10,000 Units of Antitoxin. (Park and Williams on Pathogenic Microorganisms, Lea and Febiger.)

attaches itself directly the the cells, even at low temperatures, and is increased during immunization, is called sensitizing substance, interbody, amboceptor, or immune body. The other, which is sensitive to heat, is present in the healthy normal serum, is not increased during immunization, and which unites with the cells' protoplasm only at temperatures above the freezing-point, is called alexin, or complement.

The immune body attaches itself to the cellular substance, but does not appreciably harm the cells. The complement destroys the cells after the immune body has made the cell vulnerable.

According to Ehrlich, the immune body first unites with the protoplasm of the cell and this develops in the immune body an affinity for the complement and the two unite. (See Fig. 3377.) He believes that it is through the immune body that the complement exerts its action on the cell. Very similar to the immune body is the substance called opsonin. This unites with the cell, but instead of making it sensitive to the complement it makes it sensitive to some ferment contained in the leucocytes.

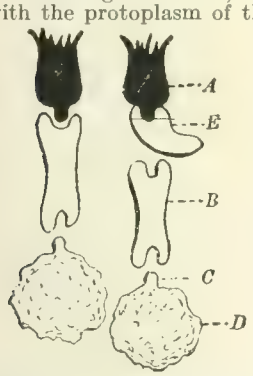

Fig. 3377.—Graphic Representation of Amboceptor, or Receptor of the Third Order, and of Complement, showing on left the immune body uniting complement to foreign cell and on right the action of anticomplement, binding complement: *A*, complement; *B*, intermediary body; *C*, receptor; *D*, cell; *E*, anticomplement. (Park and Williams on Pathogenic Microorganisms, Lea and Febiger.)

Bordet's Theory.—Bordet supposes that, instead of the tissue cell receptors which have combined with the toxin or foreign cell substance (antigen, haptine) producing an excess of similar receptors, the body of the animal that is immunized, instead of reproducing old receptors in large amount without changing them, builds up substances which in their character resemble but are not identical with preexistent principles. These new substances have become endowed with a more marked affinity for the specific antigen in question. Bordet considers that Ehrlich, in offering explanations which seem definitive, has caused certain problems which have scarcely been touched upon to be regarded as settled. According to Bordet, Ehrlich is wrong in attributing such special properties to the immune body alone rather than to both antigen and immune body to an equal degree. He states that, "as a matter of fact, these phenomena should be related, not as regards antigen or antibody considered separately, but as regards the complexes which result from their union, and it is evident that the special properties of the antigen must affect markedly and perhaps to a preponderating degree the qualities of such complexes. Just as the union of agglutinins with microbes produces in them a remarkable sensitivity to the agglutinating effect of electrolytes by modifying their property of molecular adhesion, in a similar way sensitizers confer on their antigens a similar modified property of adhesion, namely, alexin absorption." In his opinion, antibodies, whatever their nature, act very much alike; but the effects which they produce differ with the antigen in question.

Most of the experiments which have been made with the purpose of clearing up these difficult problems have been made upon red-blood cells. Here the absorption of the immune bodies at low temperatures and the lack of noticeable injury until the complement is added at a suitably high temperature is very striking.

Multiplicity of Immune Bodies and Complements.—The immune bodies are very numerous and fairly specific in their action. The complement substance is much less specific and, although probably multiple, when chemically considered, each variety acts upon widely different bacteria and cells after they have united with the immune body. There is little reason to think that the complement of one animal is any more capable of attacking cells prepared by immune bodies developed in its blood than by immune bodies developed in some other species.

Relation between Virulence and the Building of Immune Bodies.—It is probable that organisms which have recently caused infection produce in somewhat different degree the poisons they are capable of elaborating than do similar ones which have grown for a long time on artificial media, and it is necessary therefore, in immunizing experiments, to test by experiment each variety before substituting stock vaccines for freshly isolated cultures. Many varieties of bacteria stimulate the production of antibodies equally well whether they have been grown on artificial media or have been recently isolated. It must be remembered that increase of virulence for one species of animal does not mean increase for all animals; so that in order to draw conclusions, the animal upon which the virulence is tested must be the same variety as the one being immunized.

Origin of Antibodies.—Many types of cells undoubtedly produce antibodies, but some more than others.

The cells of the spleen, bone marrow, lymphatic organs and connective tissues seem to be among the most active producers of antibodies.

Wassermann and Citron tested the blood and peritoneal fluids of immunized animals for antibodies. Those receiving intravenous injections had a greater concentration in the blood, and those having received intraperitoneal injections the greater in the peritoneal fluid. In another case they amputated the ear of a rabbit after having previously injected into the tissues of the ear typhoid bacilli. The antibodies, which were increasing in the blood before the amputation, began immediately after the operation to diminish. Römer instilled abrin in a rabbit's eye and found antitoxin developed in the retina of that eye, while the other eye developed none. These facts as well as many others prove that antibodies are developed by various types of cells, when influenced by the absorp-

tion of the bacterial substances and that the cells retain a portion of the produced antibodies.

Origin of Complement (Alexin).—The cells which have abundant nuclear substance, such as the leucocytes and lymph cells, seem especially to be a source, and Metchnikoff asserts their preëminent rôle as the producers of both complements and immune bodies. Buchner and others have found that after injection of bacterial filtratep the leucocytes were attracted in great numbers to the region of injection, and that the fluid here, which was rich in leucocytes, was more bactericidal than that of the blood serum elsewhere. Some claim to have demonstrated that along with increased leucocytosis there is a general increase in the complement in the blood; still, it has not yet been positively established that the complement is derived solely from the leucocytes, nor from all leucocytes, and a mere increase in them does not always mean an increase in the complement.

Multipartial or Polyvalent Sera.—Microbes are not homogeneous masses of protoplasm, but are made up of various molecules which differ biologically from one another. Conforming to this, the antisubstances, immune bodies (antitoxins, opsonins, etc.), which appear in a serum are made up of the sum of the antibodies which correspond to these partial elements in the microorganism. These separate groups are called "partial groups." An immune serum, therefore, consists of the partial groups which correspond to the separate partial elements of the microbial body. We are further able to show that these partial elements in one and the same microbial species are not the same for all individuals of that species. Thus one culture of streptococci or of *Bacillus coli* may have a few partial elements which differ from those of another culture. What is the consequence of this? The consequence will be that when we immunize with a culture *a* of such bacteria we shall obtain a serum which acts completely on this culture, for in this serum all the partial elements present in culture *a* are represented. If, however, we employ culture *b*, *c*, or *d*, which perhaps possesses other partial elements, we shall find that the serum does not completely affect these cultures. As already stated, such a condition of things is met with in inflammations due to streptococci and other bacteria, and is, therefore, of considerable practical importance. It is because of this fact that a serum from an animal immunized to one culture acts best only in a certain percentage of cases. In order to overcome this difficulty in persons infected with these bacterial species we have no choice but to make sera, not by means of *one* culture, but by means of a number of different strains of the same species. The result of this will be that, corresponding to the various partial elements in these different cultures, we shall obtain a serum containing a large number of the partial groups. Such a serum will then exert a specific action on a large number of different cultures, but not quite as great an influence on any one as if only that variety had been injected.

In other words, the development and the closer analysis of the problem of immunity, especially during the past few years, have shown us that we must make use, more than heretofore, of so-called *polyvalent* or multipartial sera. In the serum therapy of streptococcus infections, of dysentery, etc., the production of such multipartial sera is an advantage in practice. Owing to these partial groups also, a serum—*e.g.* antityphoid serum—can specifically affect to a very slight degree a closely allied species of bacterium, like *Bacillus coli*, for example.

The Role of the Leucocytes.—The theory of Metchnikoff, that the leucocytes were the only actual protective bodies which warded off disease, and that they did this by attacking the bacteria, was founded on the fact that certain of the white cells possess the power of taking up into themselves pathogenic bacteria, which are there destroyed. It was later observed that these cells have the property of taking from the blood many lifeless foreign elements.

The question thereby arose as to whether these cells engulfed and then killed the bacteria, or whether perhaps other substances previously prepared them before the cells took them up. The latter supposition was found to be the fact. Neufeld called these substances *bacteriotropins*, and Wright, *opsonins*. The leucocytes and the chemical substances of the blood thus both play an important part. The death of the bacteria also liberates positive chemotactic substances, and the disintegration of the white-blood cells gives rise to bactericidal bodies. We find that phagocytosis is most marked when the disease is on the decline or the infection mild, but is usually absent in rapidly increasing infection. This would seem to indicate that the course of the infection is often already determined before the leucocytes become massed at the point of its entrance. The first determining influence is given by the condition of the tissues and the amount of bactericidal substances contained in them, and then, later, in cases where the bacteria have been checked, comes the additional help of the leucocytes. If the tissues are wholly free of bactericidal and sensitizing substances, neither they nor the leucocytes, nor both combined, can prevent the bacterial increase. The simple engulfing by the cells of bacteria is not necessarily a destructive process. Metchnikoff believes that the polymorphonuclear leucocytes are especially antibacterial in relation to acute infections. The large phagocytes are conceived to deal chiefly with the resorption of animal cells and with immunity to certain chronic diseases, such as tuberculosis.

The present great interest in the subject of the opsonins is largely due to the investigations and influence of Wright. We should, however, recognize the important earlier work of others. Denys and Leclef had previously shown that in the case of rabbits immunized against streptococci, the increased phagocytosis was due to an alteration in the serum and not to changes induced in the leucocytes. They demonstrated that the leucocytes of the immunized animal when placed in normal serum showed no greater phagocytic activity than normal leucocytes did, and that therefore the substances in the serum favoring phagocytosis united with the bacteria. Wright and Douglass definitely showed that phagocytosis of bacteria in normal serum depends upon a special substance in the serum which becomes fixed to the bacteria and then prepares them for phagocytes. They called this substance opsonin. Neufeld and Rimpau discovered the same point independently. Wright dealt mostly with normal serum, while Neufeld used serum from immunized animals.

Wright originated the idea of estimating the changes in the opsonic power of the blood for the purpose of guiding the use of vaccines in the treatment of bacterial infections. Thus he states:

"I have found that there exists in the serum of the successfully inoculated patient an increase of opsonin. This is a substance which lends itself to very accurate measurement by a modification of Leishman's method. By the aid of this method the patient's progress or regress can be very accurately followed."

Where vaccines are injected Wright states there supervenes a negative phase where there is a diminished content in protective substances. This is succeeded by a positive phase. This inflowing wave of protective substances rapidly flows out again, but leaves behind in the blood a more or less permanently increased content of protective substances. When a small dose of vaccine is given the negative phase may hardly appear, but the positive phase may be correspondingly diminished. Where an unduly large dose of vaccine is inoculated the negative phase is prolonged and much attenuated. The positive phase may in such a case make default.

It will be obvious that, if we, in the case of a pa-

tient who is already the subject of a bacterial invasion, produce by the injection of an excessive dose of vaccine a prolonged and well-marked negative phase, we may, instead of benefiting the patient, bring about conditions which will enable the bacteria to run riot in his system.

An immense amount of investigation has revealed the fact that the index cannot be obtained accurately enough to be a safe guide in single tests to be used in diagnosis or treatment unless the variation from the normal is exceptionally great and that the opsonic content is not a safe guide for the measure of the total antibodies in the blood.

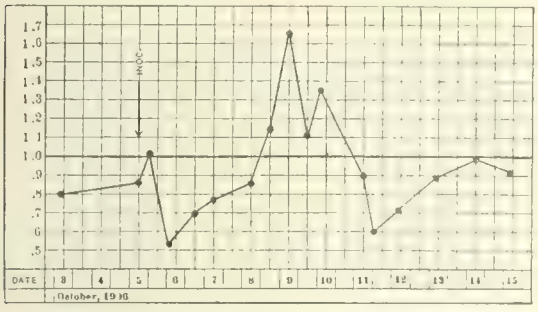

Fig. 337S.—Opsonic Curve Showing the Slight Immediate Rise and the Later Negative and Positive Phases Following Inoculation. The changes here are more regular than usual. (Park and Williams on Pathogenic Microorganisms, Lea and Febiger.)

Observation of the Relation of the Course of Infection to Phagocytosis.—The death of the bacteria liberates this positive chemotactic substance, and the death of the leucocytes gives rise to an increase of the non-specific bactericidal bodies. Thus we find that phagocytosis is most marked when the disease is on the decline or the infection mild, but that in rapidly increasing progressive infection it is usually absent. This would seem to indicate that the course of the infection is already determined before the leucocytes become massed at the point of its entrance. The first determining influence is given by the condition of the tissues and the bactericidal substances contained in them, and then later, in cases in which the infection is checked, comes the additional bactericidal substance given off by the attracted leucocytes. In so far as the tissues themselves are unsuitable for the development of bacteria they are sufficient to ward off infection, but in proportion as they are incapable of doing this they are assisted by the substances contained in the leucocytes. If the tissues are wholly adapted for the growth of the bacteria, neither they nor the leucocytes, nor both combined, can furnish sufficient protective substances to prevent the bacterial increase. The entrance of bacteria into the leucocytes, which is not infrequent, may mean the destruction of the former; but, on the other hand, the bacteria may increase in the white blood cells and destroy them, and they may be killed without entering the cells. The simple absorption by the cells is not necessarily a destructive process.

Immunity to Poisons.—No explanation can as yet be given of natural immunity to bacterial poisons, except that it may be connected with some general property of the protoplasm of the cells which renders a combination between certain molecules of the cell and the poison impossible; thus, if tetanus toxin is injected into a susceptible animal it has been found that it will disappear from the blood in a few minutes. If the cells are subjected to suitable processes the tetanus poison will be found present in all the cells except those of the nervous system. In these it has apparently disappeared. As these are the cells that received injury from the toxin it is fair to assume that some chemical combination has occurred between them and the toxin. There is far less variation among different species in their resistance to the bacterial poisons than in their suitability for the growth of the living bacteria which produce them. Possibly certain organs, such as the lymph glands, the liver, etc., may have some destructive power with regard to poisons.

Nature of Virulence.—By what means are virulent bacteria enabled to increase in the body, when non-virulent organisms of the same species are incapable of so doing? This is but little understood, but experiment shows in the first place that both virulent and non-virulent forms are equally resistant to general destructive agencies; and, secondly, that the bacteria are capable of producing substances which prevent access of immune bodies or neutralize them. The virulence of bacteria would, therefore, depend partly upon their ability to produce these poisons, which act perhaps as the ferments upon the antibodies, or perhaps combine with them. That bacteria under certain conditions form specific poisons, and under others, even when they grow luxuriantly, do not, is clearly shown by our experiments on the production of diphtheria toxin. Here it was found that when the bouillon was either a little too alkaline or too acid, though the bacilli grew rapidly, they did not produce specific toxins. When the bacilli were grown for a time in such bouillon they eventually became able to develop toxin in a soil in which they previously failed to do so. Similar cultivation in the body may be assumed to increase their ability to produce specific poison after a while under what would at first be adverse conditions.

Ehrlich's Theory of the Production of Antibodies.—According to Ehrlich the production of antitoxins and of the specific portion of bactericidal sera is due to overproduction of molecules in cells sensitive to the toxins or bacterial cell products. Ehrlich considers that toxin molecules have what he calls haptophore atom groups which find in sensitive animals cells and atom groups having for them an affinity. The groups unite and later the poison or toxophore atom group of the toxin molecule having been assimilated acts upon the vital part of the protoplasm of the cell, and injury results. This injured cell substance is replaced by the cell in excess, and this excess is thrown off free in the blood. This free cell substance has affinities similar to what it had in the cells and so unites with the toxin molecules, and satisfying them, neutralizes their poisonous properties.

When the substance of bacterial cells is injected into a susceptible animal body, there results in the same way as with toxins an injury of certain cell molecules, and an attempt at repair, with usually an overproduction. The specific substances produced cannot alone attack living bacterial cells similar to those whose protoplasm has previously caused the injury. To destroy the bacterial cell, besides the specific "antibody" there is needed a complementary body. This is the substance normally present in all healthy sera. The two substances together, uniting with the bacterial cell, destroy it.

According to Ehrlich these specific substances are present in minute amount in all living animals. After an injection or a series of injections, that one which has affinity for the poison or bacterial protoplasm is enormously increased. These atom groups of the large molecules of certain body cells are "side chains" as it were, which stand in the same relation as the side chains of the aromatic attachment to the benzol nucleus. On the ability of these groups to unite lies their tendency to be poisoned or to protect.

The agglutins seem to have a close resemblance to, if they are not identical with, the antibodies, which together with the complementary bodies destroy the bacteri.

Ehrlich's "side-chain" theories have helped greatly

to establish that the protection given by antitoxic and bactericidal serums is due, for the most part at least, to purely chemical action, the antitoxins uniting with the toxins, and the bactericidal antibodies and complementary bodies combining with the bacterial cells.

The Production of Sera for Therapeutic Purposes.—The injection of toxins and bacterial poisons is followed after forty-eight to ninety-six hours by the development of protective substances. The immunity reaches its height a week or ten days after the injection, and then continues for a week or two, when it slowly declines again. When protective sera are injected the immunity is greatest at the time of the injection and then gradually lessens. The immunity following serum injections is frequently called passive immunity and that due to bacterial or toxin injections active immunity.

If a greater quantity of protective substance is desired in the blood than occurs after one infection, repeated injections of living or dead bacteria or their products are given, the doses being administered at short intervals and in sufficient amount to produce a slight elevation of temperature and malaise. Then, as soon as the animal returns to a normal condition, another injection of slightly greater quantity is given. After several months of such treatment the blood is withdrawn, allowed to clot, and the serum then siphoned off aseptically and stored either with or without the addition of preservatives.

Testing of Immunizing Value of Sera.—The serum is tested by mixing it with a certain number of times the fatal dose of a culture or its toxins whose virulence or toxicity is known, and then injecting this under the skin, in the vein, or into the peritoneum, according to the nature of the bacteria to be tested. The main point is that some definite method be carried out by which the relative value of the serum can be judged in comparison with other serums. As a rule, the value is stated in the number of fatal doses of culture or of toxin which a fraction of a cubic centimeter of serum will prevent from destroying the animal. It is well to remember that with a living germ a multiple of a fatal dose is not as much more severe than a single dose as the figure would suggest. One thousand times a fatal dose of a very virulent microorganism will be neutralized by several times the amount of serum which a single fatal dose requires, since in the case of very virulent living bacteria whose virulence is due to their ability to increase, it is not the organisms which are introduced that kill but the millions that develop from them. As a rule, the serum has to be given before the bacteria introduced into the body have multiplied greatly. After that period has elapsed the serum usually fails to act. The immunity conferred on a person from serum lasts from a few days to several months, according to the amount of serum injected. As in animals, it is strongest immediately after absorption. An injection of bacterial poisons or the contraction of actual disease usually confers immunity in from one to three weeks after the infection, which lasts, according to the nature of the infection, from one month to a year or more. The serum loses all appreciable protective value as measured in test animals in the usual doses before the person is liable to infection. Repeated injections of serum continue this condition of immunity indefinitely.

Inherited Immunity.—Natural immunity pertains more to species than individuals, and such immunity is handed down by the parents to their offspring. If the immunity of one or both parents has been acquired by them during their lifetime previous to the birth of the offspring the immunity conferred is wholly through the mother. In the case of the female parent factor comes into play after the fructification of the ovum—viz., the absorption of products from the fluids of the mother, for the placenta is no barrier to soluble substances. Thus, sheep which have been immunized to anthrax have moderately immune young, and those possessing antitoxins transmit a portion to their offspring. Antitoxins injected into the parents pass the placenta, giving thus a passive immunity which gradually lessens and disappears in six to twelve months. A slight immunity is also given by immune mothers through their milk, a small amount of antitoxic substance being absorbed from the intestines during the first few days of life. When the parent is immunized by the injection of sera from animals of another species the immunity transmitted is much less and lasts for a few weeks only.

William H. Park.

Impetigo.—This is an acute specific inflammatory affection of the skin, spontaneously and experimentally inoculable, contagious, and epidemic; characterized by the formation of superficial flaccid vesicles which soon rupture and give place to crusts formed by the drying of the effused serum. These crusts are without inflammatory areola and look as if stuck on the sound skin, the underlying epidermic erosions healing in a few days without leaving cicatrices.

Impetigo is a disease peculiar to infants and young children, not that there is with them any special underlying predisposing cause in the soil, so to speak, such as a strumous or lymphatic condition as is often alleged, but that simply their skins are more delicate, particularly that of the face, where the corneal epidermis is less thick and where impetigo occurs most frequently.

Given an erosion of the skin—and the thinner the skin the more easily does erosion occur—and the introduction of the special germ, a characteristic lesion of impetigo will result. The *accidental* causes which lead to this inoculation are those that conduce to scratching by which the skin is broken, such as phthiriasis, especially of the scalp, and scabies. Eczema may lead to impetigo. The contagiousness of impetigo was clinically established by Devergie and experimentally proven later by Tilbury Fox, of London, and others. Fox prefixed the term contagious, which would make it appear that his "contagious impetigo" was a different affection from the impetigo of the French school, which is not the case. Impetigo and "contagious impetigo" are one and the same disease and "contagious" is an entirely unnecessary and confusing qualification. Through the more or less intimate association with the greater opportunity for contagion that takes place in schools and families, impetigo may become epidemic solely through the inoculation of one by the other of the members of such bodies. The direct and efficient cause of impetigo is a microorganism—one of the streptococci.

The elementary lesion of impetigo is an erythematous spot but slightly if at all elevated, varying in size from the head of a large pin to that of a split pea. This lesion is very transitory and gives place in a few hours to a superficial flaccid vesicle containing a clear limpid serum. The thin corneal covering of this blister-like lesion is easily ruptured, spontaneously or by scratching, allowing to exude a limpid serum which quickly coagulates and forms the characteristic honey-like crusts that appear as if stuck on the sound skin. An accumulation of these friable amber-yellow crusts, without surrounding inflammatory areola, over the cheeks, forehead, and chin, and around the lips, presents a classical picture of the disease known as impetigo. It may occur on any part of the body, but the face is the familiar location. At times, after the breaking of the imperfect vesicle, little or no exudation will take place, so that no crusts are formed, there being merely a thin glaze over the underlying superficial erosion which heals quickly, leaving an erythematous spot that slowly disappears. This abortive attempt is noticed more frequently in grown persons. Ordinarily through successive reinocula-

tions an attack of impetigo will last for from three to four weeks. The burning and itching, though slight, are sufficient in a child to cause it to scratch the lesions, thereby infecting the finger nails, and thus transference to other parts is effected with the establishment of new lesions. When uncomplicated, the lesion of impetigo never suppurates and terminates, after falling of the crust and the gradual disappearance of the underlying reddened area, without cicatrix.

Impetigo may be diagnosed from varicella by the more widespread distribution of the latter, impetigo being essentially regional; the vesicle of varicella is smaller and more prominent, is surrounded by a wide area of erythema, and dries up into smaller and far less bulky crusts.

From ecthyma the diagnosis is made by the distribution of the lesions of the latter on the covered portions of the body, and by the greater intensity of the inflammatory process in ecthyma with accompanying indurated base, wide inflamed areola around the crust-covered pustule, and deeper erosive action upon the skin.

A bullous impetigo—a rare form—has at times been erroneously reported as "acute pemphigus in children."

A crusted impetigo lesion may simulate a syphilide, especially when situated around the mouth and chin in adults; if the lesion is one of syphilis the crust on being removed will be found to have surmounted a papule or a sanious ulcer.

Treatment is simple and effective. Removal of the crusts by soaking in olive oil until they are easily detached is the first step, after which an application, renewed twice daily, of a five- to ten-per-cent. ointment of ammoniated mercury will complete the healing in a few days, leaving only the after-redness which in turn gradually disappears. This treatment is all-sufficient, and while there are many other remedies that will perhaps cure as well, there is none better than this. CHARLES TOWNSHEND DADE.

Impotence.—See *Neuroses, Sexual.*

Impregnation is "the action or process of making pregnant, *fecundation*" (Murray). It includes the two functions, copulation and fertilization. The former is an adaptation to fertilization within the oviduct, and is described in another article (*q.v.*). *Fertilization* is the essential part of the process. It is a special case of *syngamy*, a phenomenon exhibited almost universally by organisms of all grades, by plants as well as by animals, whether unicellular or multicellular. Syngamy is the union of two cells, *gametes*, to form a new cell, *zygote*. When the gametes are alike their union is called *isogamy*, or conjugation; when they are unlike the process is called *anisogamy*, or fertilization. In all multicellular animals, metazoa, fertilization occurs as a part of the life-cycle, and is the first step in the development of a new individual. The gametes differ in size and structure. The smaller more active *microgamete* is the *spermatozoon*, the larger inactive *macrogamete* is the *ovum*, and the zygote is the *fertilized ovum*. (See articles *Germ-Cells*, *Maturation*, *Ovum* and *Spermatozoon*.)

For many centuries the process of fecundation was wrapped in the deepest mystery. Although spermatozoa were discovered as long ago as 1677 by Hamm and Leeuwenhoek, and were believed by them to be germs which enter the egg, the first step toward gaining actual knowledge of the process was the discovery of the possibility of artificial fertilization by Jacobi in 1764. Before this the spermatozoa were believed by many to be merely parasites. Their name was given to them by von Baer with this idea in mind. The position of the "ovists" was strengthened by the discovery of parthenogenesis by Bonnet, who published in 1762 the results of experiments begun in 1740, which showed that in some cases an embryo can be formed without a male parent. Jacobi's work was followed by a remarkable series of experiments by Spallanzani (1786), which proved among other things that the seminal fluid when deprived of spermatozoa by filtration is sterile. But not until fifty years later did the memorable experiments of Prévost and Dumas (1824) establish the fact that the spermatozoa are the essential factors in fertilization. While these keen observers of the latter half of the eighteenth century and the first half of the nineteenth did much necessary preliminary work in this direction, they so far failed to clear up the mystery that it was possible for Johannes Müller to write in his "Physiology" in 1840 that it was uncertain whether the spermatozoa are parasites or not; and, although Schwann had declared the egg to be a cell as early as 1838, it was still possible in 1875 for a distinguished zoologist, Alexander Goette, to write "that the egg is a mass of non-living yolk which, under the influence of the spermatozoon, gradually comes into a living condition." While the process is still sufficiently wonderful and mysterious, a great deal has been done during the past forty years to render it intelligible.

The first great discovery was made by Oscar Hertwig, who observed in 1875 that the egg of a sea-urchin, *Toxopneustes lividus*, is normally fertilized by the entrance of a single spermatozoon, and that the spermatozoon gives rise to a nucleus which unites with the nucleus of the egg, forming by this union the segmentation, or cleavage, nucleus. We know now, as the result of numerous observations, that both the egg and the spermatozoon are living cells, and that they are morphologically equivalent, except in so far as they are altered in form in adaptation to a physiological division of labor, the principal difference being that the egg is provided with a large amount of cytoplasm, often heavily laden with food yolk for the nourishment of the embryo, and has no power of locomotion; while the spermatozoon is totally devoid of food material and has but little cytoplasm, most of which is usually modified to form a flagellum or other organ by which the spermatozoon may move actively and seek the egg. There is another physiological difference which will be noticed in connection with the determination of *sex* (*q.v.*). In many animals the spermatozoa are of two kinds, one of which produces male and the other female offspring. In a few animals this function appears to reside in the eggs instead of the spermatozoa. The terms male and female nevertheless cannot be applied properly to these cells, and should be used only as descriptive of the organisms that produce them or their equivalents.

Fertilization, then, consists in the union of a spermatozoon with an egg, into which the spermatozoon enters. The immediate effects upon the egg are two: (1) the initiation of development and (2) the increase in the number of chromosomes from the haploid to the diploid number by the addition of the chromosomes in the head of the spermatozoon to those in the egg nucleus. (See *Chromosome* and *Maturation*.) That these two effects are independent is shown by the fact that the development of the egg may be started without fertilization, either normally, as in the aphids and bees, or by artificial stimulation (see *Parthenogenesis*); and fertilization need not be followed immediately by development, as in the case of the winter eggs of Rotifers, Cladocera, and Aphids.

Results of fertilization that can be seen only after the development of the egg are (1) the determination of sex and (2) the mingling of parental characteristics in the offspring (see *Heredity*).

The process of fecundation consists of two main steps: (1) the approach of the gamites and (2) the union of the gametes, syngamy, or fertilization proper.

1. *The Approach of the Gametes.*—The eggs and spermotozoa of animals are brought together in a great

variety of ways, which, however, fall into two main groups, according as fertilization occurs (*a*) outside or (*b*) inside the body of the mother. The simplest manner is the discharge of eggs and spermatozoa at the same time into the water. This is the method of many aquatic invertebrates and fishes. The male Amblystoma deposits spermatozoa, inclosed in spermatophores, on submerged sticks and leaves, whence they are taken by the female into her cloaca. In frogs and toads there is a copulation, during which the male embraces the female and ejects sperm upon the eggs when they are discharged. In the arachnids, insects, some fishes and amphibia, and in all reptiles, birds, and mammals the seminal fluid containing spermatozoa is transferred from the male to the female organs during coitus. The physiology of this complicated function is described in another article (see *Copulation*).

We have then to consider how the spermatozoa, after the semen has been transferred to the female, attain the ovum. They are found in mammals after copulation in the vagina and even in the uterus, but it is not clearly ascertained how they get beyond the vagina. It is probable that they travel through the female passages by their own locomotion, and enter the Fallopian tubes, directed by the ciliary currents of the oviduct. According to Lott, human spermatozoa swim at the rate of 27 mm. in 7.5 minutes. They are found in considerable numbers in the Fallopian tubes. The ovum meanwhile travels down the oviduct.

The meeting point or site of impregnation in placental mammals is about one-third, perhaps one-half way down from the fimbria to the uterus. It is remarkably constant for each species. Nothing positive is known as to the site of impregnation in man, but it is probably in the first portion of the Fallopian tube. It may be rarely on the surface of the ovary or even in the Graafian follicle. There is no good evidence that fertilization ever takes place in the uterus.

In the sexual reproduction of plants the germ cells are brought together in a great variety of ways; and in the higher forms the process is complicated by an alternation of generations. It will suffice for our present purpose to note that in many of the lower plants the male germ cell is an actively motile *spermatozoid*, homologous with the spermatozoon of animals, on the one hand, and with the germ cell of the pollen grain in higher plants, on the other hand.

The earlier observers assumed without any very exact evidence that the ovum exerts a specific attraction upon spermatozoa of the same species. We observe, in fact, when artificial fecundation is employed, the spermatozoa swarming around the ova as if held by an irresistible impulse. This phenomenon occurs with every class of animals, even in mammals, whose freshly removed ova were examined on a warm stage under the microscope (Rein). Stassano has maintained that the eggs of echinoderms do exert such an attraction and also a similar but less strong attraction upon the spermatozoa of allied species. Very suggestive in this connection is Pfeffer's discovery that certain chemical substances may attract moving spores, etc., to definite spots. Later observers, on the other hand, have denied that there is such an attraction, and fertilization has generally been regarded as purely a matter of chance. Lillie (1913), however, has demonstrated that such attraction exists between eggs and sperm in two widely separated species—a marine worm, Nereis, and a sea-urchin, Arbacia. If water in which eggs have lain for some time, or a clump of fresh eggs, be introduced as a drop into a suspension of sperm of the same species, an immediate and well-marked chemotactic response may be observed.

Many eggs when ready for fertilization are either naked or covered by only a thin vitelline membrane, and the spermatozoon appears to be able to enter at any point. In other species the eggs are provided with an impenetrable covering, in which there is a single small opening, the *micropyle*, through which spermatozoa may enter.

Although the egg is surrounded by numerous spermatozoa, as a rule one only is permitted to enter (*monospermy*). If by accident or experimental interference several spermatozoa gain entrance (*polyspermy*) the course of development becomes deranged. The method of preventing polyspermy will be discussed in the next section. In some animals with large eggs filled with yolk several spermatozoa usually enter the egg (*physiological polyspermy*). This occurs in some insects, selachians, reptiles, and birds. In these cases, however, only one of the spermatozoa that enter actually unites with the egg nucleus. The others sooner or later disintegrate.

2. *Syngamy.*—In this step in the process of fertilization Loeb (1913) and subsequently Lillie (1911) have recognized two phases: (*a*) the first phase begins when the first spermatozoon touches the egg (*insemination*) and ends with the penetration of the spermatozoon into the egg; (*b*) the second phase begins with the penetration of the sperm and ends with the formation of the cleavage spindle. These phases differ somewhat in the two main types of fertilization, which, as was first pointed out by Hertwig, depend upon the time of insemination. In type A insemination occurs after the egg has passed through

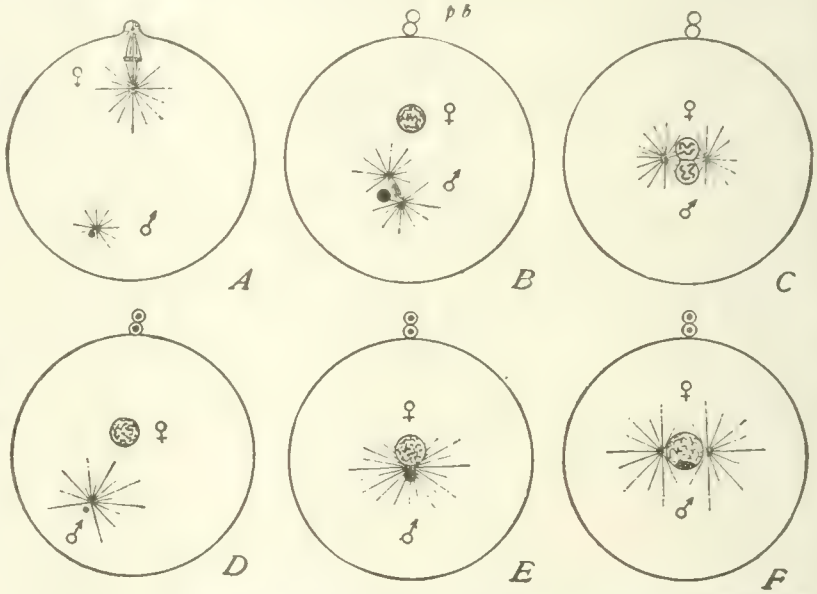

FIG. 3379.—Diagrams of Two Principal Types of Fertilization. *A*, *B*, and *C*, Polar bodies formed after the entrance of the spermatozoon, as in Nematodes, Annelids, and Mollusks; *D*, *E*, and *F*, polar bodies formed before entrance of spermatozoon, as in Echinoderms. Egg nucleus at ♀, spermnucleus at ♂. (From Wilson.)

the whole process of *maturation* (*q.v.*), as in the echinoderms (Fig. 3379, D. E. F.). In type B, seen in the eggs of flat worms, annelids, and mollusks (Fig. 3379, A. B. C.) the whole process of maturation takes place after insemination, that act being the stimulus necessary to set the process in motion. Between these two types there are various intermediate forms.

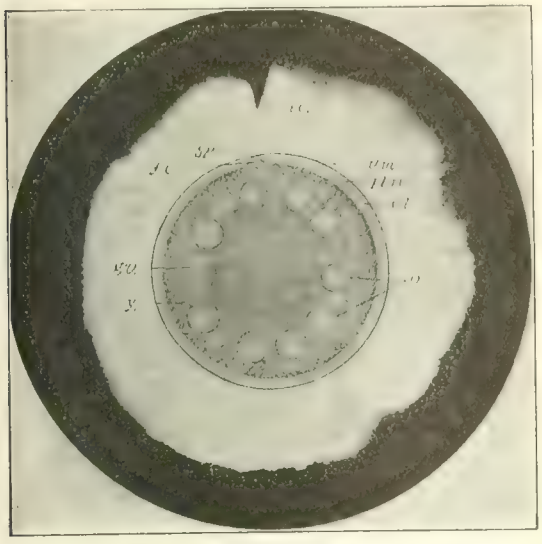

Fig. 3380.—Egg of Nereis Fifteen Minutes after Insemination in Ink. The black outer circle represents the ink, the clear area between the ink and the egg is the jelly. *c.l.*, cortical layer; *f.c.*, fertilization cone; *g.v.*, germinal vesicle; *i.c.*, ink cone; *o.*, oil drops; *pl.m.*, plasma membrane; *sp.*, spermatozoon; *v.m.*, vitelline membrane; *y.*, yolk. × 450. (After Lillie.)

a. First Phase.—When the first spermatozoon touches the egg a sudden change occurs in the cortex of the egg, which is described by Loeb as a "cytolysis," or partial dissolution of the peripheral layer. It is described by R. S. Lillie (1911) as an *increase in permeability*. This is followed quickly by the extrusion of a substance that forms around the egg, a *fertilization membrane*, or similar structure. In Nereis (Fig. 3380) this takes the form of a thick layer of colorless, transparent jelly, which pushes away

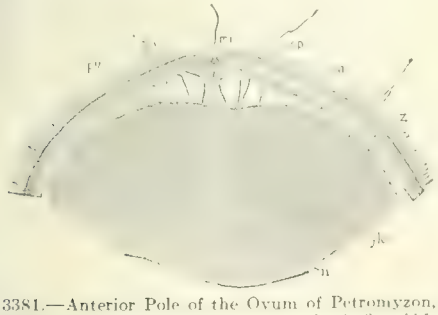

Fig. 3381.—Anterior Pole of the Ovum of Petromyzon, with a Spermatozoon (*sp*)., entering the Micropyle (*mi*). (After Calberla, *p.v.*, Perivitelline space; *z*, zona pellucida; *a*, pathway to egg nucleus, *n*; *yk*, yolk.

from the egg all spermatozoa except the effective one. Between the membrane and the egg is formed the *perivitelline space*. At the point where the effective spermatozoon is attached the cytoplasm of the egg rises in a protuberance, the *fertilization cone*. It crosses the perivitelline space, and into its tip the apex of the spermatozoon becomes firmly attached (Figs. 3380, *f.c.*, 3381, and 3382), after which the cone retracts, dragging the spermatozoon after it. In the meantime in eggs of type B the process of *maturation* has begun. The *penetration* of the spermatozoon is described by Lillie (1912) as occurring rather suddenly in Nereis about forty or fifty minutes after insemination, at the same time as the end of the first maturation division or the extrusion of the first polar body. It appears from the study of sections that the fertilization cone with the spermatozoon attached is engulfed by the cytoplasm of the egg. In this process the spermatozoon is pulled in through an opening smaller than itself in the vitelline membrane, so that it is drawn out into a thread. The egg, not the sperm, appears to be the active agent in the penetration.

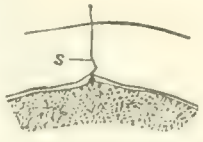

Fig. 3382.—Egg of Toxopneustes, with entering Spermatozoon (*s*), and a Protuberance of the Cytoplasm rising toward it. After Sobotta.)

In some animals the whole spermatozoon enters the egg; in others the head and middle piece enter and the tail is left outside; in Nereis, according to Lillie, the head only enters, leaving both tail and middle piece without.

b. Second Phase.—The process during the second phase differs somewhat according as the eggs are of type A or type B. The eggs of echinoderms belong to type A. Before insemination the egg nucleus has assumed the form of a spherical vesicle, and the aster and centrosome of the second maturation spindle have disappeared. The spermatozoon may enter the egg at any point. Soon after entrance the head of the spermatozoon revolves end for end and begins to enlarge, while a series of lines appear in the cytoplasm radiating from the position of the middle piece. These radiations form the *sperm aster*, and

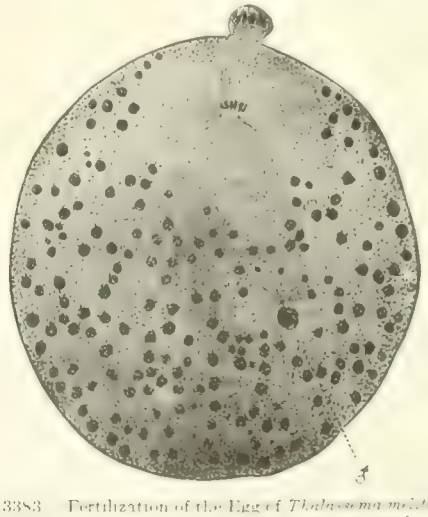

Fig. 3383.—Fertilization of the Egg of *Thalassema mellita*. The head of the spermatozoon preceded by the sperm aster is shown at ♂. The formation of the first polar body is nearly completed and the inner centrosome of the polar spindle has divided preparatory to the formation of the second polar amphiaster. Highly magnified. (After Griffin.)

at their center there is a small darkly staining spot, the *sperm centrosome*. The head of the spermatozoon, now called the *sperm nucleus*, moves rapidly toward the *egg nucleus*, preceded by the aster. The latter touches the egg nucleus and divides into two, and shortly after this the sperm nucleus unites with the egg nucleus, the two becoming completely fused in a single segmentation, or *cleavage, nucleus*. In the meantime the two asters formed by division of the sperm aster have taken up positions at opposite poles of the nucleus. Soon the nuclear membrane disappears, chromosomes and spindle are formed, and the

first cleavage begins. In this type of fertilization the two nuclei are of unequal size, the sperm nucleus being much the smaller.

The second type is seen in the eggs of flat worms, annelids, and mollusks (Fig. 3379, *A*, *B*, *C*). While

Fig. 3384.—Later Stage of the Same. The egg nucleus is shown at ♀ and the sperm nucleus at ♂. The two nuclei are approaching one another. The egg centrosome has vanished, while the persistant sperm centrosome has divided forming two centrosomes with asters. (After Griffin.)

the two polar bodies are being formed, the sperm nucleus advances to the center of the egg and becomes greatly enlarged, and at the same time the sperm aster divides to form an amphiaster (Fig. 3383). At the completion of the second polar division the egg nucleus is reformed and moves toward the sperm

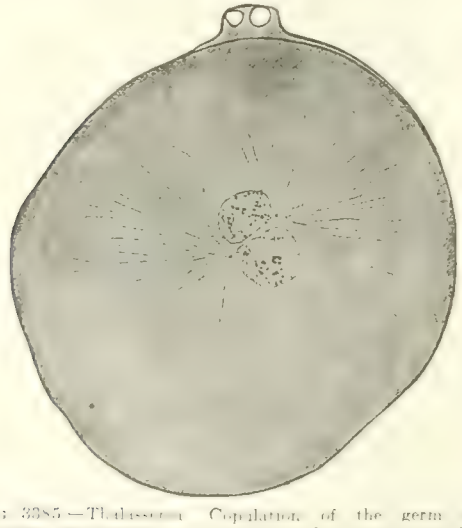

Fig. 3385.—Thalassema. Copulation of the germ nuclei. The sperm centrosomes are seen in the plane separating the two nuclei. (After Griffin.)

nucleus (Fig. 3384). The egg aster and centrosome disappear. Finally the two nuclei, now of equal size, lie side by side, but without fusing, with the two asters derived from the sperm aster lying in the plane between them (Fig. 3385). Soon after this the chromosomes reappear in each nucleus, the nuclear membrane fades away, and the first cleavage spindle is formed as before (Figs. 3386, 3387, and 3388).

Between these two types there are various intermediate forms in which the entrance of the spermatozoon occurs either after the extrusion of the first polar body or during some other phase of the process of maturation.

The account given in the preceding paragraphs should be taken as merely a general statement of the

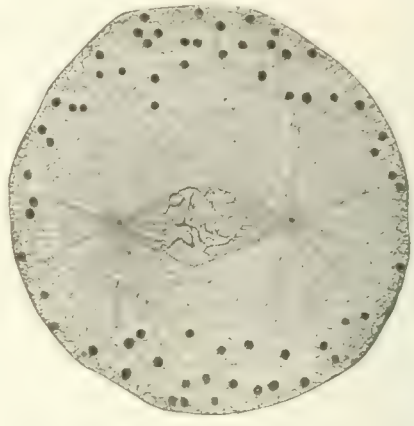

Fig. 3386.—Thalassema. The first cleavage amphiaster. Germ nuclei completely fused, with the chromatin in the spireme stage. (After Griffin.)

main facts of fertilization. The details of the process vary to a greater or less degree in different species. In the slipper shell, Crepidula, for example, the protoplasm flows toward the upper pole of the egg, while the yolk becomes more concentrated in the lower part. This is true probably, more or less, in all eggs that divide unequally. In such cases the union of the germ nuclei takes place near the center of the protoplasmic mass.

Fig. 3387.—Thalassema. First cleavage spindle in the late prophase. Chromosomes forming at the equator. The centrosomes have begun to divide preparatory to the second cleavage. This section passes through the plane of the two polar bodies, which are seen at the upper pole of the egg. (After Griffin.)

In the first type of fertilization it is impossible to trace the history of the chromosomes of the cleavage nucleus. But in many cases of the second type it is possible to do this very clearly. The eggs of Ascaris are known to be especially favorable objects as the result of the brilliant researches of Boveri, Van Beneden, and Herla. In such cases it has been shown beyond a doubt that of the ordinary chromosomes in the cleavage spindle, one-half are derived from the

egg nucleus of maternal origin and the other half are in like manner derived from the sperm nucleus of paternal origin (Fig. 3389). Now during the mitosis preparatory to the first cleavage, each chromosome is divided into two and the halves separate to opposite

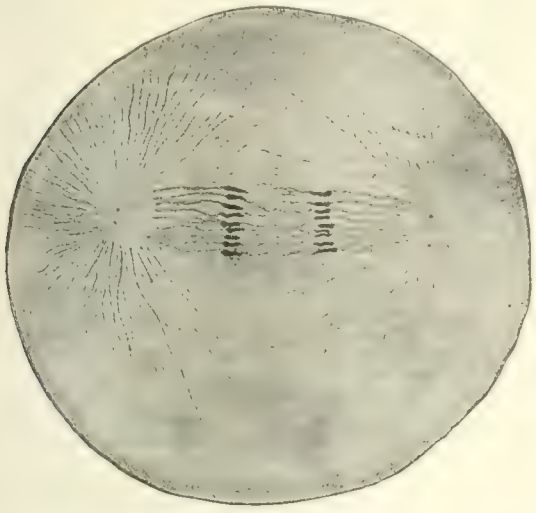

Fig. 3388.—Same as Fig. 3387. Cleavage spindle in the anaphase. The chromosomes have divided and are separating to opposite poles. (After Griffin.)

poles of the spindle, so that each daughter nucleus receives an equal number of chromosomes of maternal and of paternal origin (Fig. 3388). The same thing occurs in all subsequent mitoses. Therefore if the chromosomes maintain their individuality during the resting stage, as there is reason to suppose they do (see *Chromosome*), each somatic cell is provided with chromatin derived in equal measure from the two parents. This is a fact of the greatest importance for our theory of heredity (see *Heredity*).

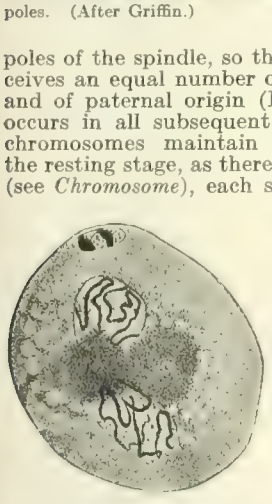

Fig. 3389.—Fertilized Egg of *Ascaris megalocephala* var *bivalens* just previous to the formation of the cleavage spindle. Two elongated chromosomes have appeared in each germ nucleus. The two large centrosomes are surrounded by extensive masses of granular archoplasm, and the second polar body is visible in the upper part of the section. Highly magnified. (After Boveri.)

The origin and fate of the centrosomes of the cleavage spindle have been fruitful of much discussion. The majority of observers are agreed now that the centrosome accompanying the egg nucleus after the separation of the second polar body usually disintegrates and disappears before the union of the two nuclei (as seen in Fig. 3384). The sperm centrosome which appears near the sperm nucleus soon after the entrance of the spermatozoon appears to be derived from the middle piece, which in turn was formed from the centrosome of the spermatid (see *Spermatozoon*). At any rate, it appears in the position of the middle piece, or near it. But because of its minute size it cannot, as a rule, be supposed to represent more than a part of the middle piece. Some observers have asserted that it is a new structure that arises in the cytoplasm of the egg as a result of a stimulus from the spermatozoon, with which it has no morphological connection. This view is confirmed by Lillie, who finds that in Nereis the middle piece does not enter the egg at all. Moreover by centrifuging eggs at the proper stage he is able to break off part of the head of the sperm. But it makes no difference whether the whole or part of the head enters, a centrosome and aster appear in the typical position. He infers, therefore, that the formation of the centrosome is due to a reaction between the sperm nucleus and the cytoplasm of the egg.

The fate of the sperm centrosome is also a matter of doubt. At least in most cases it has been impossible to show conclusively that this centrosome gives rise to the centrosomes of the cleavage amphiaster. It may disintegrate, and a new centrosome may arise in the cytoplasm close by the united nuclei. But Griffin has asserted positively that in the gepherian worm, Thalassema, he has been able to trace the history of the sperm centrosome continuously to the formation of the cleavage amphiaster. The centrosomes of this amphiaster pass one into each daughter cell during cleavage, and frequently each one divides into two before the first cleavage is complete, in anticipation of the second cleavage (Fig. 3388). This process is continued during subsequent cleavages; so it appears that the centrosomes of the first cleavage amphiaster give rise by division to the centrosomes of all the cells of the embryo, at least for a number of cell generations.

As to the mechanism by which the development of the egg is initiated, we have three principal hypotheses: (*a*) the centrosome hypothesis of Boveri, (*b*) the lysin hypothesis of Loeb, and (*c*) the fertilizin hypothesis of Lillie. Boveri regards the sperm centrosome as the especial fertilizing agent introduced into the egg by the spermatozoon. That is, while the sperm nucleus introduces the physical basis for heredity of the paternal characteristics, it is the centrosome that furnishes the stimulus necessary to start the segmentation of the egg and development of the embryo. Boveri finds evidence for this view in certain abnormal phenomena called partial fertilization. He observed that in sea urchin eggs it sometimes happens that the sperm centrosome gets so far ahead of the sperm nucleus that it conjugates with the egg nucleus and causes the egg to divide before the union of the two nuclei. The sperm nucleus, however, subsequently unites with one of the nuclei of maternal origin in the two-cell stage.

Loeb thinks that the spermatozoa carry a lysin or enzyme that affects the egg in the same way that the fatty acids and other substances do which he finds efficacious in producing artificial parthenogenesis. (See article *Parthenogenesis*.)

In opposition to both Boveri and Loeb, Lillie (1914) has evolved a complicated hypothesis founded on Ehrlich's theory of immunity. He regards fertilization as involving a chemical interaction of the ovum and the spermatozoon. It is a reaction between three bodies, of which one is born by the sperm, one by the egg, and a third body which is secreted by the egg and reacts with both the others. The spermatozoon functions essentially as an activator of the third body, which he calls fertilizin. This is a substance that causes agglutination in sperm suspensions of the same species. When activated it enters into certain reactions in the cortex of the egg which lead to membrane formation. He regards fertilizin as composed of molecules possessing two side chains, one reacting with the sperm and called the "spermophile side chain" and the other reacting with the egg and called the "ovophile side chain." The chemical group of the sperm which reacts with the fertilizin is named the sperm receptor, and that of the egg the egg-receptor. Fertilizin is secreted by the ripe eggs of the sea-urchin, Arbacea, until fertilized, when the secretion suddenly ceases. Secreted with it is a chemotactic substance that attracts spermatozoa. The eggs produce another substance, antifertilizin, that is not normally secreted but may be extracted by distilled water or by breaking up the

eggs, and which neutralizes the fertilizin. Lillie's hypothesis is illustrated in Fig. 3390. Section 1 shows the arrangement of these substances in sperm and ripe egg. Section 2 shows the mechanism of fertilization. The sperm-receptor having united with the fertilizin activates it so that it is able to combine with the egg-receptor. This is the stimulus that induces membrane formation. At the same time the adjacent fertilizin in the egg is neutralized by antifertilizin, thus preventing polyspermy. Thus it is the egg, not the spermatozoon, that bears the substance (fertilizin) necessary for the initiation of development. Any substance that will accelerate the combination of fertilizin with the egg-receptor may start development—hence the effect of butyric acid and other substances in producing artificial parthenogenesis. This hypothesis has been partially confirmed by Glaser (1913), and has been attacked by Loeb (1914). It is too early to judge of its value.

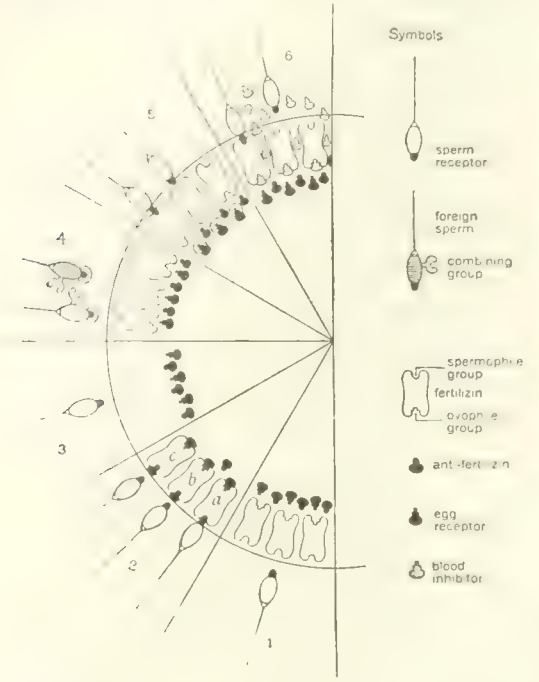

FIG. 3390.—Diagram of the Fertilizin Theory. 1, Arrangement of substances in the unfertilized egg and spermatozoon; 2, mechanism of normal fertilization; 3, Inhibition by loss of fertilizin; 4, antagonistic action of foreign sperm; 5, hypothetical; 6, inhibitory effect of blood. (After Lillie.)

Additional light is thrown on the process of fertilization by the phenomenon of *merogony*, which is the fertilization by spermatozoa of fragments of eggs containing no nucleus. Hertwig, Boveri, and others have found that if enucleated fragments of unfertilized eggs be mixed with spermatozoa of the same or closely related species, the spermatozoa will enter the fragments, the sperm nucleus will undergo regular mitotic division, the cytoplasm will divide, and larvæ will be produced that are indistinguishable from normally produced larvæ, except for their smaller size. The sperm nucleus is, then, perfectly equivalent to the egg nucleus and only needs to be supplied with the necessary envelope of cytoplasm in order to undergo the same series of changes; and under certain conditions the normal cycle of life may be inaugurated by either the sperm or the egg nucleus without union with the other, even in species in which normal parthenogenesis is unknown.

Fertilization in Plants.—The process of fertilization in plants has not been studied so extensively as in animals. But enough has been learned to show that, so far as the nucleus is concerned, the process is

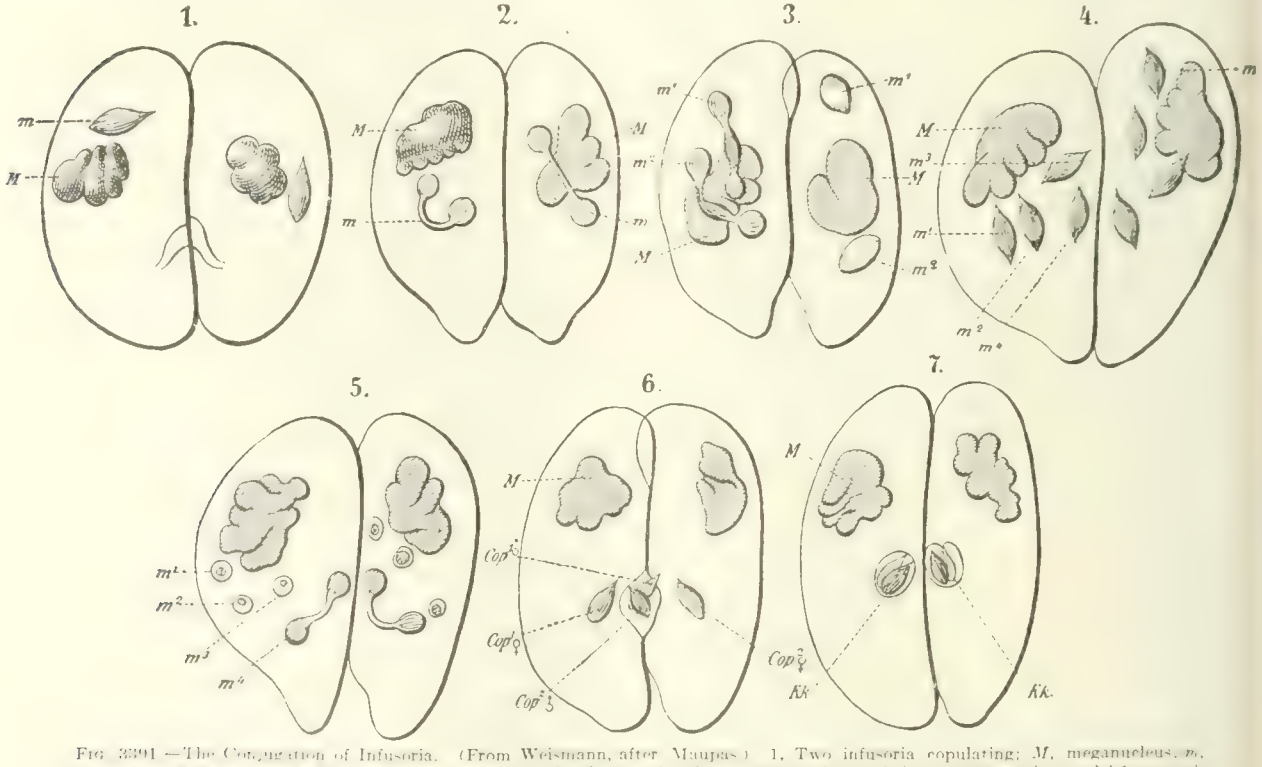

FIG. 3391.—The Conjugation of Infusoria. (From Weismann, after Maupas.) 1, Two infusoria copulating; *M*, meganucleus; *m*, micronucleus; 2–5, successive divisions of micronuclei; 6, fertilization by the migration of one of the persisting micronuclei from each infusorian into the other; 7, union of the interchanged micronuclei.

essentially the same. In the sexual reproduction of all plants that have been examined, it has been found that fertilization is effected by the union of a single germ nucleus of paternal origin with the egg nucleus. This was described for the first time by Strasburger in 1884, and his results have been confirmed by Guignard and a number of other investigators in a variety of plants of various orders. In some plants the paternal gamete is an actively motile spermatozoid, in others it is an immobile cell that reaches the egg cell by a prôcess of growth, as is the case with the pollen tube of the higher plants. But in all essential features the process is the same in both cases.

Although Guignard, in 1891, described with much detail a conjugation of centrosomes in connection with fertilization in the lily, his results have not been confirmed; and most observers have failed to find any evidence of a centrosome in any way connected with either of the conjugating nuclei of plants. This would seem to indicate that the presence of a centrosome is not essential to fertilization. But Strasburger has found that a centrosome appears in Fucus on the side of the cleavage nucleus that is derived from the sperm nucleus, and Wilson approves of his suggestion that in plants "the sperm nucleus may import into the egg either a formed centrosome (probably thus in Fucus) or a certain quantity of 'kinoplasm' which excites the mitotic phenomena in the absence of individualized centrosomes."

The pollen tube of angiosperms contains two sperm nuclei, of which only one unites with the egg nucleus. In 1898 Nawaschin published the interesting discovery that in *Lilium martagon* and *Fritillaria tenella* the other sperm nucleus conjugates with the two "polar nuclei" to form the embryo sac nucleus, the division of which gives rise to the endosperm of the seed. The same phenomenon was described more in detail by Guignard in 1899, and confirmed by Miss Sargent. It immediately occurred to De Vries, and independently to Webber that this might explain a phenomenon called *xenia* by Focke (1881). For a long time it has been known that if the pollen of one variety of maize be allowed to fall upon the silk of a different variety, the kernels in the ear may show the characters of the male parent. Until this process of double fertilization was discovered, the embryo was the only part known to have a double origin, and the appearance of the paternal characters in a part of the seed supposed to be purely of maternal origin seemed very mysterious.

From a careful study of the phenomena of xenia in maize, in which the only undoubted cases occur, Webber has reached the conclusion that they are perfectly consistent with the theory of double fertilization, no xenia appearing in characters not connected with the endosperm. But the actual double fertilization has not yet been observed in this plant.

Xenia has been supposed to be a similar phenomenon to *telegony* in animals. But it seems impossible for any such process of double fertilization to occur in animals, and Ewart has found that in the mare "the spermatozoa lodged in the upper dilated part of the oviduct are dead, and in process of disintegrating, eight days after insemination." Moreover, the supposed existence of telegony has been entirely discredited by Ewart on experimental evidence, and by Pearson on evidence from statistics.

Conjugation.—In the conjugation of the unicellular animals and plants, we find a process clearly analogous to the fertilization of the higher groups. The two conjugating cells may be similar or diverse in form. In many motile Infusoria (Fig. 3391) two similar individuals come together, exchange nuclei, each one giving off a "male pronucleus," which enters the body of the other and unites with its "female pronucleus," and then the two individuals separate. In other cases there is a motile "microgamete" that forms a permanent union with a sessile "macrogamete," comparable to spermatozoon and egg respectively. In each case the essential feature of the process is a union of two equivalent nuclei, preceded and followed by a complicated series of divisions that we need not discuss here.

Summing up the subject of the fertilization, Wilson says ("The Cell," ed. 2, p. 230): "We thus find the essential fact of fertilization and sexual reproduction to be a union of equivalent nuclei; and to this all other processes are tributary." The almost universal occurrence of this process in animals and plants of all grades, from the protozoa to man, indicates that it has some profound significance, but what this is is unknown. According to Weismann, fertilization has for its object the mingling of ancestral germ plasms and the consequent production of variability in the offspring. But Pearson, as the result of statistical investigations, holds that variability is not produced by fertilization. According to Maupas, fertilization has for its object a rejuvenescence of protoplasm, which thus wards off the senescence and "natural death" that must inevitably overtake it if fertilization does not take place; and Minot finds evidence for this view in the results of his investigations of the law of growth (see *Growth*). But when we consider the innumerable generations of domestic plants that have been produced with unimpaired vigor by cuttings, grafts, and other purely asexual methods of reproduction, the existence of any such "natural death" appears to be extremely doubtful. So while our knowledge of the details of fertilization has advanced enormously during the past quarter century, the origin and object of the process remain as mysterious as ever. ROBERT PAYNE BIGELOW.

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Incompatibility, Medicinal.—The word *incompatible*, used in connection with the mutual relations of medicines, is one of very loose application. Thus, in a sweeping way, a medicine is said to be *chemically* "incompatible" with anything that will produce a chemical or physical change in its condition, and *physio-*

logically "incompatible" with anything that produces the reverse of its so-called physiological effects. Under these definitions, however, it is evident that in many cases so-called "incompatibility" may yet not interfere at all with full medicinal power or purpose. Practically, the subject of medicinal incompatibility deals with those chemical, physical, and physiological mutual relations of medicines that require consideration in the prescription of different medicinal substances in conjunction, and such topic it is that will here be considered.

As regards *chemical* and *physical* reactions there are many which are special, between special medicines. Such must be learned in connection with the individual medicines concerned. But, also, there are certain reactions that affect broad categories of medicines, and which, therefore, admit of general consideration. Such reactions and the practical bearings thereof in prescribing are as follows:

1. *Acids and bases tend directly to combine, to form salts.* This reaction may be utilized, if it be the object of the prescriber to obtain the salt that will result from the bringing together of an acid and base; but if the purpose of the prescription be to retain free acidity or alkalinity, acids and bases must not be conjoined in prescription.

2. *Stronger acids or bases tend to displace, in the case of salts in solution, weaker bodies of their own respective kinds.* Thus, if sodium carbonate in solution be treated with nitric acid, the nitric acid will displace the carbonic to the formation of sodium nitrate in solution and the evolution of carbon-dioxide gas. Strictly speaking, the statement of this reaction is a *circulus in definiendo,* since one acid is known to be "stronger" than another only by the fact of its supplanting such other acid in saline combination in solution. The statement, however, is a convenient reminder, to the prescriber, of a set of reactions which are of common occurrence, and whose bearing upon prescribing is as important as it is obvious.

3. *Salts in solution tend to exchange radicals; and acids or bases to displace their respective brethren in saline combination, if thereby an insoluble compound will form.* If, as the cant phrase runs, nature "abhors a vacuum," she also *delights in precipitates;* for reactions, determined evidently by the fact that a precipitate will result, are among the commonest occurrences of chemistry. Concerning this reaction it is to be noted that while precipitation may affect potency profoundly in the case of some medicines, in other cases it may make no difference or may be of distinct advantage. Thus in the case of the so-called black and yellow washes of mercury, it is a precipitate which is wanted, and which therefore is intentionally the subject of prescription. Generally, however, the occurrence of a precipitate in a medicinal mixture is objectionable; for, even if medicinal virtue be not affected, the turbidity is unsightly, and, by the settling of the precipitate as the bottle stands, doses drawn, on the one hand, from the full or, on the other, from the nearly empty vial will vary enormously in strength of the precipitated ingredient, unless the bottle be thoroughly shaken at the taking of each dose. The table of notable mutually precipitant solutions, taken from Curtis' "Manual of Medicinal Technology" is convenient for reference. The reactions therein broadly stated as occurring with solutions of salts of the alkaloids, and of the metals, are true in the generality of instances only.

4. *Things in solution precipitate on addition of an excess of a fluid in which they are respectively insoluble.* Here, as in the former instance, precipitation may not affect medicinal potency, but yet is generally to be avoided because of the intrinsic objections to precipitates in medicinal mixtures, as set forth above. The two medicinal solvents most concerned in the present relation are *water* and *alcohol,* and the commonest instances of the reaction in question are as follows: *albuminous, gelatinous, gummy, saccharine,* and certain *saline* bodies dissolve in water but are insoluble in alcohol, and accordingly precipitate on addition of an excess of alcohol to their aqueous solution; while *alcoholic* solutions of *volatile oils, balsams, camphor,* and *resins* precipitate on treatment with excess of water.

5. *Powerfully oxidizing agents may determine explosions on concentrated admixture with readily oxidizable substances.* The exact conditions determining explosions with individual mixtures of this category will vary with the substances concerned, and must accordingly be learned with each medicine. All that is appropriate to state in this place is that the powerful oxidizers used in medicine are *chromic* and strong *nitric* or *nitrohydrochloric acids, potassium chlorate, and potassium permanganate;* while the medicinal substances of easy combustibility are *oils, alcohols,* and *ethers* (including *glycerin* and *sugars*), dry *organic* substances generally, and the elementary bodies, *sulphur* and *phosphorus.*

TABLE OF NOTABLE MUTUALLY PRECIPITANT SOLUTIONS.

	Solutions of alkalies.	Carbonic acid and solutions of carbonates.	Sulphuric acid and solutions of sulphates.	Phosphoric acid and solutions of phosphates.	Boric acid and solutions of borates.	Hydrochloric acid and solutions of chlorides.	Hydrobromic acid and solutions of bromides.	Hydriodic acid and solutions of iodides.	Solutions of sulphides.	Tannic acid.	Arsenical solutions.	Albumin.
Alkaloidal solutions (generally)	Prec.	Prec.		Prec.	Prec.			Prec.		Prec.		
Metallic solutions (generally)	Prec.	Prec.		Prec.	Prec.				Prec.	Prec.	Prec.	Prec.
Lead solutions	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.
Silver solutions	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.	Prec.
Calcic solutions	Prec.	Prec.	Prec.	Prec.								
Magnesic solutions	Prec.	Prec.		Prec.								
Albuminous solutions										Prec.		
Gelatinous solutions										Prec.		

Physiological incompatibility, as already stated, is alleged between medicines whose respective so-called "physiological" effects are mutually antagonistic. Such antagonisms are individual and peculiar, and are best discussed in connection with the individual medicines concerned. Two points alone are proper subject for mention in this place. The first is that exact antagonism in all directions of physiological action of drugs is very rare; and the second, that in practical prescribing the fact of an antagonism need not preclude the proper conjunction of two antagonistic medicines in the same mixture. On the contrary, many of the happiest of medicinal combinations are of remedies more or less antagonistic in operation; this either because the antagonism is itself serviceable in mellowing a too intense action of the dominant antagonist, or because the drugs, though antagonistic in some lines, are synergic in others, and so together yield a resultant effect better for certain

remedial purposes than the unmodified effect of either medicine used singly. An example of the former instance is the common combination of castor oil and laudanum; and of the latter, the association of atropine with morphine.

The modern tendency is toward simplicity in prescription writing; and the less that one leans toward polypharmacy the safer one is with regard to incompatibility. If one drug or preparation will serve the practitioner's purpose, he should never use more.

EDWARD CURTIS.
R. J. E. SCOTT.

Indian Hemp.—See *Cannabis Indica.*

Indian Medical Spring.—Sherburne County, Minnesota.

POST-OFFICE.—Minneapolis.

The Indian Medical Spring is situated in an ideal spot, twenty-seven miles from Minneapolis, near the village of Elk River. The water boils up through from six to eight feet of pure white quicksand, sparkling in its purity and freshness.

The following analysis was made by A. F. Irwin, Ph. G. M. D.:

Potassium bicarbonate	1.098
Potassium sulphate	.425
Magnesium bicarbonate	2.058
Calcium bicarbonate	3.654
Sodium bicarbonate	1.832
Sodium sulphate	.285
Sodium chloride	.425
Iron bicarbonate	.084
Iron phosphate	.003
Alumina	.030
Organic matter	.562
Silica	1.056
Total	11.512

The water contains sulphureted hydrogen which escapes on standing. Analysis shows that it is a very soft, mildly alkaline water. It is beneficial in disorders of the stomach and kidneys, in constipation, rheumatism and eczema. The water is used commercially. EMMA E. WALKER.

Indian Springs, Georgia.—POST-OFFICE.—Indian Springs, Butts County. Several hotels in village. The Wigwam is the principal one. Boarding houses.

ACCESS.—Via Southern Railway to Flovilla, thence two and one-half miles by dummy line to spring. This celebrated spring received its name on account of its great reputation as a medicine spring among the Indians. In the treaty of 1821, when all this portion of Georgia was ceded to the whites, a special reservation of one thousand acres, including Indian Spring was made by the Creek nation. This, however, was given up to the whites a few years later. A village of several hundred inhabitants has sprung up in the neighborhood. The above analysis was made by George F. Payne, M. D., F. C. S., State Chemist of Georgia.

	Grains Per U. S. Gallon
Potassium bromide	0.0113
Sodium iodide	0.0009
Sodium phosphate	0.0032
Ammonium chloride	0.0072
Lithium bicarbonate	0.1933
Potassium chloride	0.1326
Sodium chloride	1.3872
Sodium sulphate	2.9582
Magnesium bicarbonate	0.8373
Calcium bicarbonate	3.2842
Sodium bicarbonate	1.9592
Sodium silicate	0.5235
Silicon dioxide	1.4150
Iron sesquioxide	0.0297
Organic and volatile	0.8863
Total Solids	13.6291
Carbonic Acid combined with Carbonates to form Bicarbonates	2.4237
	11.2054
Free Ammonia	0.04 part per million parts
Albuminoid Ammonia	0.06 part per million parts
Hardness	3.50 degrees.
Reaction	Alkaline.

The sulphureted hydrogen gas was not present in the water after it had stood some time. This analysis represents the bottled water as received at the laboratory.

The waters are used both internally and externally. There is a swimming pool 25 × 100 feet. Among the numerous affections in which the water has been found useful may be mentioned dropsical conditions when not due to heart disease; rheumatism, gout, Bright's disease, acid dyspepsia, many skin diseases, and tertiary syphilis.

The climatic conditions are most favorable.

EMMA E. WALKER.

Indian Springs, Indiana. ACCESS, via Chicago, Terre Haute and Southeastern Railroad to Indian Springs station, thence three miles by stage to the springs.

POST-OFFICE.—Indian Springs, Martin County. Hotel. Conveyances meet all trains during the season. The resort is located eight miles north of Shoals, the county seat of Martin County.

The therapeutic value of the waters of these springs has been known for years, and they were in great repute among the aborigines. The springs were first opened to the public as a health resort in 1814, and they have maintained their reputation ever since. They have their source along the course of Sulphur Creek, which wends its way through the surrounding valley and empties into the Indian Creek one mile distant from the hotel. The surrounding country is hilly and quite picturesque. The following analysis has been made of the water at Indian Springs:

	Indian Springs	Trinity Springs
Calcium carbonate	8.76	5.84
Magnesium carbonate	Trace	Trace
Magnesium sulphate	25.46	14.71
Calcium sulphate	24.82	71.07
Magnesium chloride	1.40	14.83
Sodium chloride	None	None
Sodium sulphate	18.65	32.82
Total solids	79.09	139.27
Hydrogen sulphide	0.64	0.42

This water is a powerful chalybeate, also a fairly strong alkaline-saline water. EMMA E. WALKER.

Indianapolis.—The largest city and capital of Indiana with a population of 233,650, is situated near the center of the State, 195 miles southeast of Chicago. An index of its climate is here given for the sake of reference and comparison.

As will be seen, it is a temperate climate, with considerable seasonal extremes and diurnal fluctuations of temperature. The humidity is not high, and the rainfall is moderate. More than a quarter of the days in the year are clear, more than a third fair, and about two-thirds clear and fair.

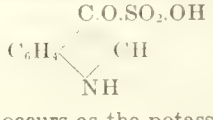
Such a climate is well-situated for a residence for those in ordinary health. For the delicate or sick, a change might be advised to escape the cold of the winter

CLIMATE OF INDIANAPOLIS, IND. LATITUDE, 39°46'. LONGITUDE, 86°10'. PERIOD OF OBSERVATION, ELEVEN YEARS NINE MONTHS.

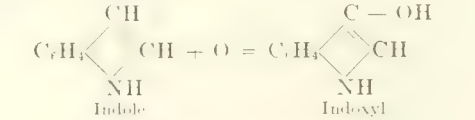
	February	March	May	August	November	Year
Temperature—						
Average of normal	29.9°	40.3°	64.4°	74.3°	40.7°	53.2
Average range	15.1	16.3	18.9	18.4	14.0	
Mean of warmest	36.5	49.9	73.8	82.9	49.1	
Mean of coldest	21.4	33.6	54.9	64.5	35.1	
Highest on record	69.0	77.0	89.0	101.0	75.0	
Lowest on record	22.0	9.0	31.0	48.0	−5.0	
Humidity—						
Average relative	73.6%	67.0	60.3	68.5%	69.9	67.7
Wind						
Prevailing direction	W.	N. W.	S. E.	S.	N. W	N. W
Average hourly velocity in miles	6.4	7.3	5.7	4.5	5.8	5.7
Weather—						
Average number clear days	5.3	6.5	9.5	11.0	6.1	94.8
Average number fair days	10.5	10.6	12.5	14.1	10.2	142.4
Average number clear and fair days	15.8	17.1	22.0	25.1	16.3	237.2

and the heat of the summer, and in order to obtain purer air than a city affords. As the elevation is low, a change also to a high altitude might be beneficial for various morbid conditions. EDWARD O. OTIS.

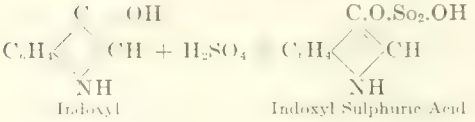
Indican.—Indoxyl-sulphuric acid.



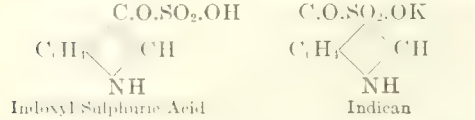
This compound occurs as the potassium salt in urine being derived from indole formed in the intestine as the result of putrefactive processes. Indole thus formed is absorbed, carried to the liver, and after oxidation to indoxyl is conjugated with sulphuric acid. The reactions involved follow:



Indole — Indoxyl

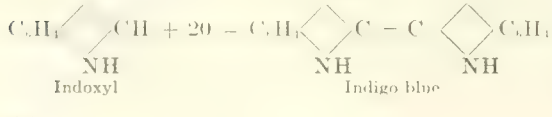


Indoxyl — Indoxyl Sulphuric Acid



Indoxyl Sulphuric Acid — Indican

By treatment with concentrated hydrochloric acid indican is transformed into sulphuric acid and indoxyl. The latter body may then be oxidized to form indigo blue in accordance with the following reactions:



Indoxyl — Indigo blue

This reaction is the basis for the test and quantitative estimation of indican in the urine, the indigo blue being extracted from the urine with chloroform. Indican having its origin in putrefaction in the intestine may be taken as a measure of the extent of putrefactive action in the alimentary canal. Under various pathological conditions within the organism the same reaction may occur, giving rise to the appearance of crystals of indigo blue in the urine. After subcutaneous injection of indole the quantity of indican in the urine is markedly increased and it may be greatly augmented by the introduction into the organism of orthonitrophenol propiolic acid. The putrefaction of secretions of the intestine explains the elimination of indican during starvation. Gelatin does not increase the elimination of indican for the reason that this substance does not contain the tryptophane group which is the mother substance of indole, whereas most proteins contain a considerable quantity of this group. In those diseases where the small intestine is obstructed there is also an increased elimination of indican. FRANK P. UNDERHILL.

Indicanuria.—Indican, indoxyl sulphate, $C_8H_6NSO_2OH$ is a chromogen that occurs physiologically in normal urine, as the potassium or glycuronic acid salt, in quantities varying from 4.5 to 19.5 mg. in the twenty-four hours, averaging 6.6 mg. per 1,000 c.c. of urine in a series of eight observations reported by Jaffé. Such small quantities do not respond to the tests ordinarily employed for the excessive presence of indican.

Indican is a derivative of indol, and is formed within the body through the action of microorganisms. Senator declares that indican does not occur in the urine of the newly born. In experiments upon the dog, indican disappears from the urine following the exhibition of large doses of calomel, according to the observation of Beauman.

Tuzzek studied the effect of restricted diet in insanity and found indican in the urine only when albumins were ingested. When the ileum is brought into an artificial anus, thus sidetracking the large intestine, indican disappears largely or altogether from the urine, to reappear normally upon the obliteration of the artificial anus and the reestablishment of the alimentary flow through the large intestine.

Indican in the urine increases physiologically under meat diet and is lowest under a milk or kefir diet. The nucleus of the indols, tryptophan, is normally present in the proteins and is converted into indol through the action of microorganisms. Indol, C_8H_7N, is usually present in the intestinal tract, but is excreted in the urine only when present in considerable quantity in an intestine that is not normal. At any rate it would appear that only very small quantities may be absorbed by the normal intestine.

Indol absorbed from the intestinal tract becomes oxidized, forming indoxyl, which combines with sulphuric acid and is excreted in the urine as the potassium or glycuronic acid salt of indoxyl sulphate.

The indoxyl derivatives are comparatively non-toxic. Other products of nitrogenous putrefaction, such as ptomains, leucomains, phenol, cresol, and skatol, are notably toxic. For these other substances we have no simple test, so that it has become a common practice to estimate the presence or degree of intestinal putrefaction by testing the urine for indican. The value and reliability of this method would seem to be indicated by the observations of Jaffé, that there are microorganisms capable of producing both indol and phenol on albuminous media, that other microorganisms produce only phenol and others produce neither indol nor phenol, but that there are none that produce phenol that do not produce indol.

Baar found indicanuria in all cases of achlorhydria, so long as free hydrochloric acid was absent from the stomach contents. This he explains as follows:

Bayliss and Starling showed that the normal hydrochloric acid of the stomach, upon entering the duodenum forms secretin out of the prosecretin contained in the cells of the duodenal mucosa. This secretin, according to Enriquez and Hallion, enters the circulation and stimulates the pancreas to secrete. The pancreatic secretion in its turn causes the secretion of succus entericus; this contains enterokinase, originating from the duodenal glands, and erepsin, originating lower down in the intestines; these two latter ferments then activate trypsinogen (which is contained in the pancreatic secretion) to trypsin, whereupon the pancreatic secretion becomes proteolytic. If, then, as in the cases of achlorhydria, there is no hydrochloric acid, there will be no secretin formed in the duodenal mucosa and, consequently, there will be no pancreatic secretion brought into the intestinal tract and no secretion of succus entericus. In other words, the normal proteolysis is disturbed and the ever-present bacteria have an opportunity to form putrefactive products out of the undigested proteins, and we shall find indicanuria as an expression of their excessive formation.

In this connection it is interesting to note the observation of Simon, that there is an increased indication of indican in the hyperchlorhydria of gastric ulcer, whereas indicanuria is not found in hyperchlorhydria of nervous origin. The highest grades of indicanuria are observed in ileus. Gross indicanuria does not occur in simple uncomplicated constipation.

The pathological occurrence of indicanuria is found in achlorhydria and hypochlorhydria, especially in carcinoma of the stomach; in acute, subacute, and chronic gastritis, and as stated, in the hyperchlorhydria of gastric ulcer; in ileus, acute and chronic peritonitis, conditions in which there is marked lessening of the peristaltic movements of the small intestine. Diseases of the large intestine are peculiarly free from indicanuria. It is held that indicanuria may be caused by albuminous putrefaction within the body in cases of empyema, putrid bronchitis, gangrene of the lung, etc.

Indicanuria is a common symptom of epilepsy and other neuroses, in which it occurs in connection with secretory insufficiency. Chorea and neurasthenia may show indicanuria due to secretory insufficiency. Baar has called attention to the frequency of indicanuria in the cases showing the evidences of hypoplasia described by Bartell, viz., hyperirritability of the vasomotor system (erythema pudicitiæ, dermatographia), hyperflexibility of the metacarpophalangeal joints, large tonsils, high, narrow hard palate, uvula bifida, heterologous sexual characteristics; with woman the masculine type of hair growth, lanugo on the cheeks and upper lip, long hairs in the axilla, upper arms and thighs hairy, the hairs on the mons veneris extending into the linea alba instead of being horizontally limited, perineum hairy, pelvis masculine, lower extremities of masculine length, hypoplastic mammæ, strongly developed lower jaw; or in men the feminine type, scant hair growth in the face, on breast and pubic region, cubitus valgus, etc. In these cases there is probably a hypoplastic condition of the secretory glands and the mucous lining of the gastrointestinal tract.

Cases of gastroenteroanastomosis, appendectomy, enteroanastomosis, cholecystectomy, cholecystostomy, show indicanuria from the first day of the operation until the intestinal wall is healed. In short, all anatomical lesions of the gastrointestinal tract may show indicanuria.

Repeated examination of the twenty-four hour urine for indican will reveal obscure lesions of the gastrointestinal tract in many cases that would otherwise not be recognized.

Tests for Indican.—The Obermayer reagent, composed of ferric chloride in concentrated hydrochloric acid, 1:500, affords one of the simplest tests. Equal volumes of urine and Obermayer reagent are shaken in a test-tube with a small amount of chloroform. In the presence of indican, the chloroform takes up the indigo blue, so that the depth of color indicates in a rough way the amount of indican present in the urine.

The Jaffé test as modified by Stokvis. To equal quantities of urine and concentrated hydrochloric acid, in a test-tube, two or three drops of a strong solution of sodium or calcium hypochlorite are added and the mixture is shaken with a small amount of chloroform. The chloroform is colored blue, the depth of color indicating the relative amount of indican in the urine. Albumin does not interfere with this test, but any bile pigment should be removed by means of a solution of lead subacetate.

The treatment of indicanuria depends upon the cause. Cases due to defective secretion of hydrochloric acid may be relieved by gastric lavage, washing the stomach with a 1:1000 solution nitrate of silver, or by the administration of dilute hydrochloric acid. The intestinal cases may often be relieved or cured by high colonic lavage with a one per cent. solution of ichthyol. In any case it is advisable to curtail the proteins in the diet. Constipation, though no longer accredited with its former importance in the causation of indicanuria, should nevertheless be corrected if present. Often an appeal to surgery must be made, as in chronic appendicitis, cholecystitis, and ulcer of the duodenum or stomach.

Fortunately, in many cases it suffices to place the patient upon a carbohydrate diet with a liberal allowance of milk culture of the lactic acid bacillus. Animal experimentation justifies the use of the intestinal antiseptics, especially the initial dose of calomel in cases of constipation. GEORGE E. MALSBARY.

Indigo Blue.—See *Indican.*

Indigo, Wild.—BAPTISIA, *Dyers' Green Weed.* Under these names, the herb and more particularly the root of *Baptisia tinctoria* (L.) R. Br. (fam. *Leguminosæ*) has been more or less used in domestic, and to a slight extent in professional medicine. Its common names come from the fact that it has been used as a poor substitute for indigo.

The plant is a large, much-branded perennial herb, very abundant in sandy soil, especially in the borders of woods, throughout the Eastern United States. It is said to contain two glucosides, *baptin* and *baptisin*, and the poisonous alkaloid *baptitoxine*, which is believed to be identical with *cytisine*. According to the dose, the properties vary from stimulant, increasing peristalsis and acting as a laxative, to irritant, producing purging and vomiting. Upon the nerve centers, it is primarily stimulant, secondarily depressant or paralyzant, and causing death by paralysis of respiration. Its use has been chiefly, both systemically and locally, in diphtheria, scarlet fever, and sore throat. The dose of the fluid extract is ♏ xv. to lx. (1.0 to 4.0). HENRY H. RUSBY.

Indole.—$C_6H_4\begin{smallmatrix}CH\\ \\ NH\end{smallmatrix}>CH$. This substance is formed from protein by the action of putrefaction in the alimentary canal and also in rotting mixtures. It, together with skatole, methyl indole, yields to feces and to putrefying flesh their peculiar disagreeable odors. The mother substance of indole is in the tryptophane group of the protein molecule. After absorption, oxidation, and conjugation with sulphuric acid, indole is eliminated in the urine in large measure as indican. Indole crystallizes in shining plates with a melting point of 52° C. It is volatilized by steam and may be removed from the watery distillate by ether. An alcohol solution of indole treated with hydrochloric acid colors a pine chip cherry red. (See *Indican.*)
F. P. U.

Infancy.—Under the term *infancy* (inability to speak) we include that early period of life which extends from birth to the close of the first dentition. Its first few weeks represent a period of great feebleness during which there exists a liability to special forms of disease consequent upon the great change which takes place in the circulation at birth, and upon the assumption by the several organs of their special work in the economy. To the infant at this period the name of "the new-born" (neonatus) is applied. From the end of the first month to the close of lactation between the ninth and twelfth months is sometimes referred to as the period of early infancy and corresponds to the term "Säuglingsalter" of German writers.

Compared with childhood and adult life, infancy is characterized by rapid growth and development. It is a period specially liable to disease, some of the manifestations of which are peculiar to it; others though similar to what we meet with in adult life, are more or less modified by the peculiarities of the infant constitution. Its mortality is much greater than that of adult life.

Anatomical and Physiological Characteristics.

The first act of the new-born is to inspire. With the separation of the placenta from the maternal connection and the tying of the cord, the whole circulation of the infant is profoundly altered; for the first time a full current of blood distends the pulmonary arteries to meet air in the newly opened vesicles of the expanding lungs. The thorax is enlarged and the diaphragm and abdominal viscera are depressed, all conspiring to favor the associated changes which take place in the heart. With the sudden deflection of blood to the pulmonary circulation and the greatly increased intrathoracic pressure, the flow of blood through the foramen ovale and the ductus arteriosus comes almost to a standstill, and both these passages become gradually obliterated. Within thirty-six hours Vogel found the ductus arteriosus scarcely large enough to admit a probe; the foramen ovale closes more slowly, the border of the valve usually remaining free for some months, but the foramen is so completely covered that no detriment to the circulation ensues. The left ventricle now takes on the burden of the systemic circulation, rapidly increasing the muscular power so that at the end of the second year its walls are double the thickness of those of the right side.

With the establishment of respiration the livid hue of the skin, due to the interference by parturition with the fetal circulation, is rapidly exchanged for the deep red of the new-born infant. This hue fades in a few days and the skin not infrequently then assumes a more or less yellow tinge unaccompanied by any symptoms of systemic disorder. This condition is known as *icterus neonatorum* its true cause is still uncertain, but it is supposed to be associated with a disturbance of the hepatic circulation due to the alteration in its blood supply. This yellow tinge gradually disappears of itself, and by the third week of life the skin assumes the rosy tint of healthy infancy. The fine soft hairs which at birth frequently cover almost the whole body generally fall out by this time and are not renewed, though feeble infants may retain them for some time. The long strong hairs on the scalp with which many infants are born fall out at a later period and are generally replaced by finer and, as a rule, lighter-colored hair. At birth the lacrymal and sudoriferous glands are inactive. It is almost impossible to produce sensible perspiration in an infant a few weeks old; not until after the third month does the activity of the sweat glands commence, but after this age in rachitic infants, perspiration is often very profuse. The sebaceous glands, on the contrary, are very active in the new-born. In the third month the secretion of those in the scalp frequently gives the vertex the appearance of having been smeared with wax, and later on forms a distinct crust of a yellowish-brown color (seborrhea capillitii). This is to be distinguished from inflammatory exudations by the fact that if a portion of the crust be removed, which can be easily done by the finger nail, the subjacent skin will be found in a healthy state, not even congested. This excessive secretion ceases spontaneously about the end of the first year, and the scabs, if still remaining, dry and crumble away.

Fat is abundant in the subcutaneous tissues of the healthy infant but is present in only small amounts in the interior of the body. The muscles in the first months are small and soft; not till after the sixth month can they be felt firm and resisting. The bones are still in great part cartilaginous and possess, therefore, much greater flexibility than in the adult.

With the introduction of air the compact tissue of the fetal lung is converted into a spongy alveolar structure of a rose-pink color and expands so as to cover in great part the pericardium and to come into contact with almost the whole extent of the thoracic wall. The approximation anteriorly of the two pleural cavities, however, is not so close as it becomes in later life, the anterior aspect of the heart and thymus gland remaining comparatively uncovered.

The thymus gland in the new-born weighs on an average from five to eight grams. Bovaird and Nicoll consider that its size and weight are at a maximum at birth, but Olivier after a series of observations, states that it doubles its weight during the first two years of life, remains about the same till the eighth year or a little longer, after which it rapidly decreases in size. Its period of greatest functional activity appears to be during infancy and early childhood. What its exact functions are is still uncertain. Recent experiments appear to indicate that it furnishes an internal secretion which exerts an important influence on nutrition. An excessive secretion has been suggested as the cause of the condition known as *status lymphaticus*, Thymectomized animals develop at first a condition of increased fat assimilation followed later on by a grave cachexia. The thyroid gland in the infant is relatively larger than in the adult.

The liver at birth is large and its lower margin is easily felt from one to two centimeters below the ribs. The stomach occupies a more vertical position than in the adult owing to the slight development of its fundus. Its capacity at birth is somewhat less than one ounce.

In the infant the shape of the duodenum is not unlike its form in adult life; its folds are less developed, and more than in the adult does it act as a digestive reservoir where the food from the stomach is mingled with the secretions of the liver and the pancreas. Below the duodenum the several portions of the intestines show considerable difference in their relative lengths as compared with those which they attain in the adult. Both small and large intestines are relatively long; Treves states that the average length of the small intestine at birth is nine feet five inches and of the large, one foot ten inches, and says there is remarkably little deviation from these figures. He estimates that the small intestine grows about two feet per month for the first few months, but after this period development proceeds irregularly, depending upon the nature of the food, the vigor of the digestive process, and the activity of the abdominal nervous centers; it bears no relation to the general growth of the body nor to the weight of the child. The position of both small and large bowel is much less fixed than in the adult; the upper part of the small bowel may frequently be found occupying the lower part of the right iliac fossa, and the caput coli may be found near the umbilicus from which position the colon ascends toward the left hypochondrium. Both ascending and transverse colons are generally very short, while the

descending colon and sigmoid flexure are of great comparative length. For the first four months the growth of the large bowel is relatively slight, but a certain amount of readjustment of its position appears to take place by which the ascending and transverse portions increase at the expense of the sigmoid flexure. After the age of four months, however, growth generally goes on steadily. Occasionally this undue length of the sigmoid flexure persists during infancy, seriously impeding the passage of the feces and leading to constipation.

At birth the kidneys are of comparatively large size and distinctly lobulated. This peculiarity in form passes away shortly. Anomalies are occasionally found. The suprarenals at birth are as large as in the adult. The bladder in the new-born has a capacity of from two to four drams and lies partly in the pelvis, and partly above it in the abdominal cavity. Renal secretion commences early, and at birth urine is normally present in the bladder and should be voided during the first twelve hours of life. During the first few weeks of life crystals of uric acid and urates, occasionally hyaline casts and epithelial cells with a minute amount of albumin, may be found in the urine, a result of the prenatal condition known as uric-acid infarction. During infancy the urine is of a light color, low specific gravity (1.004–1.010), faintly acid in reaction, and contains a low percentage of urea and of the inorganic salts. The amount of urine passed for the first few days is very variable and has been estimated at from two to three ounces, increasing in the week to five or ten ounces. Throughout infancy the amount of urine passed is relatively larger than in adult life, but is dependent upon the amount of liquid taken by the infant; micturition is very frequent.

The urethra in the male is six centimeters long, delicate and distensible and generally presents a marked constriction at the meatus. The glans penis is closely invested by the prepuce; cohesion is frequently very firm between the membrane covering the glans and that covering the prepuce. Congenital deformities due to arrested development are not infrequent. In the female infant the urethra and vagina are relatively large and distensible; the uterus is from an inch to an inch and a quarter long, but its fundus is quite undeveloped. Deformities occasionally arise from the non-absorption of the septum formed by the infolding of the cloaca. The mammary gland is well developed, possessing secreting structure in both sexes.

Although the brain of the new-born is of relatively large size the anterior lobes, and the cerebellum are comparatively small. The blood-vessels of the pia mater are abundant and very fragile, so that hemorrhage into the subarachnoid space is liable to occur not only from slight traumatism but from any cause producing high blood pressure. The brain tissue itself is most immature, of a uniform whitish color, and of soft pulpy consistence. Not till toward the first month of life does gray matter make its appearance on the convolutions. The centers in the medulla and in the spinal cord are in a much more forward state of development than those in the cerebrum, and throughout infancy maintain their functional superiority; of those in the spinal cord the motor centers in the anterior cornua are more developed than those of sensation in the posterior; to this forward state of development of the spinal centers is due the great reflex excitability of the nervous system in infants. Even in normal infants, however, much variation in the time and development of the various nerve centers may be observed.

Circulation.—The blood of the new-born for the first few days after birth resembles that of the fetus, and shows signs of immaturity. As compared with the blood of an adult its percentage of hemoglobin is very high; both the red and the white cells are present in greatly increased numbers, and a few nucleated red cells may be seen; at the same time the total amount of blood as compared with the body weight is less than in the adult. Owing to the comparatively small amount of it and to its immaturity, the young infant stands the loss of even small quantities of blood badly.

Owing to the rapidity of the developmental changes, and to the dilution of the blood by the large amount of fluid food taken by the infant, these conditions change rapidly. By the third month a normal infant has more blood in proportion to its weight than an adult; its percentage of hemoglobin is greatly reduced so that it averages between sixty and seventy-five; the red blood cells number from 4,500,000 to 5,500,000. The white blood cells are still in large numbers from 10 to 15,000, and even 20,000. Of these the mononuclear lymphocytes are in much the largest number all through infancy and childhood, a prominence due to the great functional activity of the spleen and lymphatic glands. The organs, on the other hand, which have to do with the production of the red cells during early life are taxed to their full capacity; and anemia arises from comparatively slight causes.

Although at birth the heart as a whole is relatively larger then in the adult, it has to be remembered that in intrauterine life the auricular half is unduly developed, and that after birth the walls of the left ventricle only slowly acquire that increase of power demanded by their newly assumed burden of the systemic circulation. The arterial system of the infant has also a large relative capacity as compared with the size of the heart, which, associated with a comparatively weak ventricle, renders arterial tension low. This condition persists in some degree till puberty, when it ceases owing to the rapid development of the heart at that age. It would appear that in the young growth and physiologically low blood pressure go hand-in-hand (Jacobi). It is also to be noted that the growth of the large arterial trunks in the infant is not uniform: the subclavian and carotid at birth are relatively large, corresponding with the greater development of the head and upper extremities; after birth the descending aorta and the femoral and renal arteries increase more rapidly in size, corresponding with the rapid growth of the lower extremities.

The pulse rate during infancy is much more rapid than during childhood or adult age, and is easily disturbed and quickened by slight causes; irregularity of rhythm may not infrequently be noted. A girl's pulse is almost always a few beats more rapid than that of a boy. The following table furnishes approximately the pulse rate at various periods:

Table Showing Pulse Rate at Different Periods of Infancy

At birth	From 120–140
At six months	From 110–120
At twelve months	From 105–115
At two years	From 90–105
At five years	From 80–90

Muscular exercise or excitement will increase this rate by from twenty to fifty beats.

The lymphatic system in the infant is well developed; its glands are numerous and large in size, and the intercommunication between them and the general system is more marked than at any other period of life.

Respiration in the infant, as a consequence of the circular shape of the chest, is chiefly carried on by the diaphragm. Owing to the compressibility of the chest wall, to the lack of development in the respiratory muscles, and the yielding character of their points of origin and insertion, and also to the narrowness of the upper air passages, respiration is easily disturbed and in young infants may not infrequently be observed to be irregular. The rate and rhythm of the respiratory movement are very variable; Eustace

Smith gives forty or perhaps more as the number of respirations in the new-born, but adds that they soon become less rapid. Rotch places them at about forty-five for the first weeks of life, and in infants under two years at between twenty and forty per minute. The ratio between the rapidity of the respiration and that of the pulse for the first few months of life is inconstant and easily disturbed. During infancy more oxygen is inhaled and more carbonic dioxide exhaled than in adult life, as the result of the more rapid tissue change. Infants, however, stand complete deprivation of air for a longer period than will adults. Attention is drawn by Jacobi to the greater labor required by the organs of both circulation and respiration in the infant as compared with those of the adult, while at the same time their own development must go on. Hence fatigue is more easily experienced and rest and sleep are much more urgently demanded.

The Digestive Tract.—The mouth is early moistened by secretion from the buccal and labial glands, though in the first days of life often imperfectly so. Saliva is secreted at this date only by the parotid glands; its amount for the first two or three weeks is but one-tenth of what it becomes after the sixth month; not until after the fourth month do the submaxillary glands assume activity. Even in the first days of life, pepsin is secreted by the gastric follicles in small amount. For the first few weeks the stomach is small in size, somewhat tubular in shape, and plays a comparatively unimportant part in the process of digestion, acting chiefly as a receptacle in which the milk is coagulated by the rennet ferment, and from which it passes in a comparatively undigested state into the duodenum where digestion is completed by the pancreatic ferments. While in a breast-fed infant two months old the stomach empties itself in an hour and a half, in an infant four months old the average time is about two hours. Infants fed on cow's milk require half an hour longer. At birth the average capacity of the stomach is under an ounce; the organ, however, increases rapidly in size, and by the end of the fourth week its capacity in an infant of average size is about two and a half ounces, at three months four and a half ounces, at six months six ounces, and at twelve months nine ounces. In estimating the size of the stomach of an infant, not only is its age to be considered, but also its weight; the greater the weight of the infant the greater will be its gastric capacity. After the first six months of life the secretion of gastric juice becomes distinctly more abundant, but during the entire period of infancy free hydrochloric acid is either absent altogether or exists in only small amounts toward the close of digestion in an infant's stomach. In the intestines the villi are numerous and large, even surpassing in size the corresponding structures in the adult, and contain large capillaries. The glands of Lieberkühn are present, but only in small numbers and they are poorly developed. The same is true of Peyer's glands, which do not reach their proper development till the second year of infancy. In a healthy infant the greater part of the food is absorbed from the small intestine. The mucous glands of both stomach and small intestine are more numerous in the infant than in later life, and if unduly stimulated pour forth a copious secretion which readily undergoes acid fermentation and becomes an irritant. The secretion of the pancreas is for the first few months very deficient; three of its ferments are present at birth, viz., trypsin, steapsin, and the milk-curding ferment, but the amylolytic ferment is deficient till after the sixth month. Bile is early secreted in considerable quantity, but compared with that of the adult it is defective in organic salts, in cholesterin, in lecithin, and in fat.

The feces of an infant after the first few days should be of an orange-yellow color, of soft homogeneous consistence, distinctly acid in reaction, and not offensive in odor. They are chiefly composed of fats, of fatty and lactic acids in combination with lime, of cholesterin, of intestinal epithelium and mucus, with about three per cent. of the milk ingested which has remained unabsorbed. Meconium is no longer considered to be simply an admixture of bile with intestinal mucus, but is found to contain flat epithelial cells which cannot have originated in the intestinal canal, along with fine hairs and fat globules which have evidently had a cutaneous origin.

Growth.—The average weight of the new-born babe is a little over seven pounds, males as a rule weighing a few ounces more than females, but occasionally this average is much exceeded. During the first two or three days of life a loss in weight of from eight to twelve ounces usually takes place, due partly to the passage of urine and meconium, partly to the disturbance of nutritive processes necessarily associated with its entrance on a new life, and partly to the fact that during these days the infant is not supplied with sufficient nourishment. Townsend, at the Boston Lying-in Hospital, has shown that the infants of primiparæ lose more and are slower to recover their loss than those of multiparæ; large children, however, suffer less loss of weight and recover more quickly than small ones; children who have to be fed artificially do not as a rule regain their original weight before the tenth day. That the loss is to some extent avoidable is indicated by the fact that in the young of mammals which commence to take the dug immediately after birth, increase of weight is immediate and uninterrupted. Any failure of the infant fully to regain this loss by the end of the second week should be regarded as an indication that its nutrition is at fault and special measures should be taken to increase its vitality (Rotch). After the second week there should be a weekly gain in weight of from five to seven ounces for the first five months. After this age growth gradually becomes less rapid. It is generally considered that the initial weight of the infant at birth should be doubled at five months and trebled between thirteen and fourteen months of age. The weight at one year should be doubled at six years and this weight doubled again when the child reaches fourteen years. Weighed from day to day the amount of increase in an infant may be found to vary considerably, even a uniform weekly increase is exceptional. Slight disturbances such as dentition, weaning, improper feeding, or undue excitement may interfere with or even interrupt the regular increment. The weight of an infant carefully and systematically taken is to be regarded as an excellent index of the infant's nutrition, and our most exact guide in determining the suitability and sufficiency of the food supplied. Bowditch has also insisted that actual loss in weight, and sometimes even a failure to gain, is often an early premonitory indication of the onset of constitutional disease.

The average length of the infant at birth is nineteen and three-quarter inches. During the first six months it grows from four to five inches and in the second from three to four. In the second year the gain is from three to five inches, and by the end of the fifth year the child should have doubled its original length. Insufficient nourishment and improper food, especially in rachitic children, retard growth in length. Chronic disease of the brain (idiocy) is apt to give rise to more or less dwarfing. Cretinism, also, in a very marked degree stunts growth. On the other hand an attack of one of the exanthemata appears in some children to accelerate growth.

At birth the circumference of the head much exceeds the circumference of the thorax, but with the rapid development of the lungs the difference is notably diminished during the first few months, and at the end of the first year, notwithstanding the rapid development of the head, the thorax exceeds it. When between six and eight weeks old, the child begins to raise

its head and turn it voluntarily toward a bright object and a few weeks later is able to hold it up without support. Not till about the seventh month does the average infant acquire the power of sitting alone, and not till the close of the first year are the lower extremities sufficiently developed to enable it to make some effort to stand. Two or three months later it should walk alone. Growth does not always take place uniformly; the head often increases the most rapidly in size, but sometimes the extremities. When growth is too rapid, failure of strength, with anemia and more or less emaciation, ensues.

About the sixth month dentition generally commences with the eruption of the two lower central incisors and these are followed at varying intervals by the other teeth in successive groups. Every kind of variation may be met with as to the order in which the several groups of teeth appear without any evidence being found either at the time or later, of the existence of any pathological condition, rachitic or otherwise (Rotch). Nevertheless delayed dentition is generally regarded as to some extent an evidence of imperfect nutrition. Merei and Whitehead state that in seventy-nine per cent. of the well-developed, the first teeth appear before the eighth month has passed, while in sixty per cent. of those with imperfect development the first teeth are cut after the eighth month. The following is the formula for their usual appearance as given by Rotch:

Groups.	Time of appearance.
Two central lower incisors	6th to 8th month
Four upper incisors	8th to 10th month.
Two lateral lower incisors and four first molars	12th to 14th month
Four canines	18th to 20th month.
Four second molars	28th to 32d month.

During the earlier months of infancy the anterior fontanel remains open, and affords a fair indication by its size of the state of development in the cranial bones, and to some extent of the state of ossification in the body generally; and by the presence or otherwise of any distention in the membrane covering it, of the condition of the brain, whether congested or anemic. This fontanel is of small size in the new-born, but gradually increases up to the ninth month when its size remains stationary for two or three months, and then it begins rapidly to close (Vogel). Between the fifteenth and eighteenth months in healthy, well-developed children it should become completely ossified.

The development of the senses and mental faculties in the infant is an interesting study to which in recent years considerable attention has been directed. The first movements of the new-born infant are either purely reflex, like its crying, or impulsive, and due to the unloading, in an objectless manner, of its "inherited provision of motor impulses." Tactile sensation at birth appears to be developed in lips, tongue, eyes, and hands; numerous reflexes of prenatal development also manifest themselves, *e.g.* respiration, swallowing, winking, coughing, sneezing, etc. With these exceptions sensation, both general and special, is in the early weeks of life very defective. The senses of taste and smell appear to be the first to make distinct and clear impressions on the mind. The new-born can distinguish between bitter and sweet, and the taste and smell of the milk first received makes a permanent impression, so that another is often tried only to be put away. Thus memory and judgment appear to arise first in the domain of these senses.

Hearing and sight are defective at first, but become afterward of much importance to development. All children are born deaf owing to the fact that the Eustachian tube is closed at birth and is only gradually opened by the acts of breathing and swallowing. Until it is opened the middle ear contains no air, and the tympanum stands very obliquely. After hearing becomes active no organ of sense contributes so much toward mental development. Deaf children are much more backward than are the blind. Toward the end of the third month a child should recognize the direction of a noise and turn toward it. It requires more time, however, before children can distinguish between different sounds. Demme found only two per cent. able to recognize their mother's voice at three and a half months. At six months most babies enjoy being sung to, and are amused by the jingle of rattles.

The infant appears to be able to distinguish light from darkness almost immediately after birth, but that is all, for the movements of the lids and balls are not at first symmetrical. About the sixth week a bright light, if moved slowly, is followed by the eyes, and after the third month we may observe the quick closing of the lids on the approach of an object. By this time also the child should recognize its mother's face. After the sixth month the estimation of size, distance, and color becomes gradually developed, but not till after the third year are all the colors distinguished.

Voluntary grasping is generally noticed very shortly after the third month and with it comes the knowledge of things apart from itself.

Speech is not inborn, but the tendency to it is inherited. At first only vowels are uttered, but after the first few weeks the mental state of the child may be determined to some extent from the different sounds that it makes and its voice gradually becomes modulated to suit its mood. Toward the end of the first year the child begins its first imitation of sound. The progress is more rapid after this, but for a long time expression and gestures are the most important means of communication, and sounds are merely accompaniments. Then one word is used to signify several thoughts, showing the growth of reasoning power. Two or three words are next joined together, and finally complete sentences are formulated. All the disturbances of speech noted in the adult may have their counterpart in the child. In the one the functions are disturbed by disease, in the other the defect is due to insufficient development.

Infantile Mortality.—Until very recent years the mortality during the first year of life has been appalling, amounting to about twenty-five per cent. of all infants born. In the last decade of the past century the death rate at this age for all England amounted to 180 per 1,000 born; for France 225, and for Italy 275. In America the infant mortality in all the large cities reached similar figures.

With the great improvement in the general hygienic conditions of living which has taken place in all civilized countries and the more perfect knowledge of the necessities of infant feeding and hygiene which is being diffused through all classes of society, these statistics have during the past decade been greatly reduced. How much can be done in this way is well illustrated by the statistics quoted at the Conference on Infant Mortality held in London, 1912, at which it was stated that in the well-kept parish of Hampstead in London infant mortality had been reduced to 71 per 1,000, while in the more crowded and less hygienic district of Shoreditch the death rate among infants still remained at 145 per 1,000. Still further comparing the statistics of the various classes in England it was stated that infant mortality only reached 40 per 1,000 born in the families of physicians, and 77 in the families of the upper and middle classes; it rose to 160 in families of miners and to between 150 and 250 in those of unskilled city workmen, while it fell to 97 in the families of the poorly paid agricultural laborers.

While a few of the causes of this heavy death rate are at the present unable to be foreseen and prevented;

such as prematurity, malformations, and birth injuries, the great majority can be avoided by intelligent care before and after birth, by more perfect hygienic surroundings for the infant, and by more scientific attempts at infant feeding. In the parent, the presence of syphilis or tuberculosis necessarily entails an enfeebled offspring unless effective precautionary measures are taken. Even with no diathetic disease to deal with in the mother, overwork, general debility and many chronic affections will affect unfavorably the vitality of the offspring and render it less able to withstand disease. After birth, the very defective hygienic conditions into which many babies are born predispose to sepsis and diseases of both upper and lower respiratory tracts. Under such conditions also acute zymotic disease plays an important rôle in the death rate. Pertussis has its maximum mortality during the first year of life, and measles in the second, but scarlet fever does not reach its maximum fatality till between the third and fourth years of life.

The most important factor, however, contributing to this heavy death rate is gastrointestinal disease. According to Jacobi forty-one per cent. of the mortality in the first year of life, and almost as large a percentage in the second year, is due to this class of diseases. During the past few years great efforts have been put forth both of a public and of a private character to remove and counteract the conditions which have so much to do with the production of this class of disorder. Already these efforts are bearing fruit in a greatly lessened death rate compared with that of the past.

Another important factor contributing to the high infant mortality is disease of the respiratory tract to which, according to Jacobi, twenty-one per cent. of all deaths in the first year of life, and thirty-six per cent. in the second year, are due. Imperfect ventilation of living rooms and undue exposure to wet and cold, with insufficient covering of the extremities conduce greatly to the onset of these affections.

The fact that medical science has shown that the greater part of this heavy infant mortality can be prevented by a more healthful civic environment and by the general diffusion of more exact knowledge of the important principles of infant feeding and hygiene, should stimulate all who have the good of the community at heart to increased effort to mitigate the heavy death toll due to ignorance, poverty, and an unclean milk supply.

Infant Hygiene.—As soon as the requisite attention has been given to the mother, the newly born infant demands the physician's care. Its breathing and heart action should be carefully observed; the mouth wiped out to remove any mucus that may impede respiration, and its eyes washed with either physiological saline or weak boric acid solution. Should any possibility exist of an infection by Neisser's coccus it is always wise to instil under the lids a two per cent. silver nitrate solution and then wash out with sterile water or saline solution. After the bath has been given the infant the umbilical stump requires careful aseptic dressing. It is always desirable that for the first two days the rectal temperature of the infant should be taken twice a day or oftener if there is any reason to suspect trouble

Feeding.—As soon as the mother has to some extent recovered from the exhaustion of labor, the infant should be applied to the breast. Although the full supply of milk is not established until the second or third day, yet, as a rule, sufficient will be obtained to satisfy the infant; when it is very feeble, however, artificial feeding with a weak lactose or sterile cream mixture may be advisable. At this early period the infant does not require much and a frequent application to the breast is unnecessary. Should the influx of milk be delayed and the infant be fretful, feeding with some substitute milk may be deemed advisable. For the first month it may be difficult to obtain regularity in nursing, but the importance of regular feeding should be impressed on the mother, and she should be told that crying and fretting during the intervals are in general due not to hunger, but to colic, which may be aggravated by irregular nursing. After the second month an interval of at least two hours between the periods of nursing should be insisted on during the day and until about ten o'clock at night; after that for the rest of the night one nursing only should be permitted. As the child grows older its stomach becomes capable of taking larger quantities at a time, and the intervals should accordingly be gradually lengthened to three, afterward to four hours. In some cases the breast milk of the mother does not agree with the infant and gives rise to more or less pronounced symptoms of indigestion associated with much fretfulness, sleeplessness, and either an actual loss of, or a failure to gain in weight. This condition of the milk is sometimes due to over-anxiety, insufficient sleep, an improper dietary, or irregular habits on the part of the mother, and may be remedied by securing for her a correct dietary, regular outdoor exercise, sufficient sleep and freedom from undue worry and excitement. In a few instances, however, the fault appears to be irremediable, and artificial feeding with a properly constituted food must be attempted. (See article *Infants, Artificial Feeding of.*)

In estimating the suitability of any food to an infant's requirements the important test is the weekly increase in weight. If the food is digestible, and sufficient in amount for its wants, the infant should be free from colic, happy in disposition, should sleep quietly, and gain regularly in weight. No fixed rule can be stated as to the proper time to supplement the breast milk with an artificial food. While robust mothers, with an abundant supply of milk, can easily satisfy their infants up to the age of nine or ten months, many begin to feel the drain upon them by the second or third. In others, the milk, though abundant, fails to satisfy and sufficiently nourish the child, and must be early supplemented by artificial food.

Bathing.—The first bath of the infant should be given in a warm room, free from draughts, and in water of a temperature of 96° F. The infant should be dried beneath some warm flannel covering. In general, nurses are not sufficiently alive to the necessity of preventing undue chilling of the surface. From the fifth to the ninth day the navel string becomes detached, and not till that occurs is a second general bath advisable. After that the bath should be given daily in water at a temperature of about 92° F. This temperature, after the age of eight or nine months, may be lowered carefully to 90° or even a few degrees lower, according to the strength of the infant and the vigor of its reaction. Too prolonged chilling of the surface during bathing and dressing is the frequent cause of catarrhs of all sorts.

Clothing.—In the dressing of the new-born care should be taken that there is no injurious dragging on the navel, that the usual abdominal band is not applied so tightly as to interfere with respiration or digestion, and that sufficient warmth be secured for the extremities. Later on, caution should be enjoined that none of the clothing press unduly on either chest or abdomen—all should hang loosely from the shoulders, neck bands should not be tight, and the extremities should always be efficiently and warmly covered. No sudden change in the amount or character of the clothing is, on any account, to be permitted. Special care is also to be given to the shoes. The leather should be pliable, and the shoes made broad and loose about the toes, so as to allow freedom for movement and growth.

Sleeping.—For the first few weeks of its life an infant should sleep eighteen hours out of the twenty-four. As it grows older, it gradually requires less. A fretful

and wakeful baby is ailing in some way, and the cause of its fretfulness should be found out and remedied. When possible the nursery should be large and well ventilated. For the first few days of infant life it may be desirable that the room in which it is kept should be somewhat darkened, but after that fresh air and sunlight should never be excluded. At the same time draughts and rapid changes of temperature are fraught with much danger.

Exercise is important, but the manner of it is equally so. No infant should be carried about upright until it is able to raise its head and rotate it easily; nor should it be encouraged to walk or stand till nearly a year old, and if there be any tendency to rachitis this must be postponed still later. After an infant is three months old—a little later, in the winter season—it should be "short-coated," and the fullest liberty given to its arms and legs. It should be encouraged to lie on its back in its crib with loose clothes and enjoy, as it will do, the liberty of kicking. Every day it should be taken out regularly during the more suitable portion of the day, unless the weather be too blustery.

Weaning if possible should be effected gradually. Many physicians deem it wise to accustom an infant early to one feeding of artificial food in the day, a practice which also affords to the mother a little greater liberty for any outside duties which she may have. As lactation fails these feedings may be gradually increased in number. Abrupt changes in an infant's food if possible should be avoided. When possible to select the time to make a change it is wise to avoid a period when the teeth are erupting. It is also unwise to take the breast from an infant while it is sick or recovering from an illness, unless it is quite manifest that the milk of the mother is distinctly harmful. Even an inadequate supply at such times may be all-important for the infant. Regard must also be paid to the season of the year. Any radical change during the summer months is undesirable.

In the EXAMINATION of infants tact and careful observation are necessary. All appearance of abruptness is to be avoided; no harshness in voice or manner is allowable; the physician's hands must be warm; and a full supply of patience must ever be ready to be exercised if demanded. If the infant be asleep on the physician's arrival it is wise to permit no disturbance of it, until the decubitus has been noted, the pulse and respirations counted, and their character observed, and such other superficial observations made as are possible without disturbing the infant. The pulse and respirations in an infant just awakened are always extremely rapid. With regard to its decubitus, a healthy young infant in sleeping generally assumes the position he is supposed to have had *in utero*. An older infant, even if lying on its back, generally inclines its head to one side or the other, so that its cheek comes in contact with the pillow. If it be lying with its head retracted some interference in the throat with inspiration, or cranial disease should be thought of. If it sleep on its belly, or resting on elbows and knees, it is suffering from abdominal discomfort. Healthy children should sleep quietly. Much tossing, any twitching of the muscles, or screaming and talking in sleep, indicate feverishness or digestive derangement. Much may be learned from the character of the child's cry. Unappeasable screaming, without any other symptom, often results from earache. The temperature should always be taken with a sensitive thermometer, preferably in the rectum; if not convenient there, in the groin. The armpit is not so good, as infants object to the necessary restraint of the arm. In many abdominal troubles the skin and extremities may be quite cool, yet the thermometer in the rectum show a temperature of 104° or 105°. The respirations, if practicable, should always be counted. At the first examination of an infant we should always insist on having the infant stripped, otherwise no thorough examination can be made. Care should at the same time be taken that the infant be not chilled by a too prolonged examination. Passing downward we note: (1) The shape of child's head and fate of fontanel; (2) The shape of the chest and the character of the breathing, whether there be any retraction of the chest walls or intercostal spaces; with warm hand palpation of the thorax should be made, and the presence of any rhonchal fremitus should be noted; (3) The shape of the abdomen, whether protuberant or retracted, and whether the walls are tense or lax; gentle palpation by the hand, will detect any tenderness of the abdomen or enlargement of liver or spleen; (4) The condition of the lymphatic glands.

In addition, the color and elasticity of the skin and the general nourishment of the tissues should be observed at this time. In auscultating the chest, the infant should be placed on the left arm of the nurse, leaning over her left shoulder, with its arm around her neck or lying prone across the nurse's knees, with its arms hanging down. The muscles of the back must be equally relaxed to obtain correct results. Percussion should always be gentle. Immediate auscultation never gives the exact results obtained by the use of the stethoscope, but any painful pressure by the instrument must be carefully avoided. In infants, symptoms of disease are more frequently found at the back than at the front, and at the base rather than at the apex. Nevertheless, no part should be omitted in the examination. Inspection of the mouth and fauces should always be left to the last, as it is invariably resisted by the infant. To effect this the infant should be seated on the nurse's lap before a bright window. Sometimes with a little gentle pressure on the chin the mouth is opened and the tongue seen. To examine the fauces requires the use of a depressor, for which nothing is better than the smooth handle of a spoon. This can always be slipped in behind the teeth and over the tongue to its base. When the pharynx is reached the mouth involuntarily opens, and, if the physician be on the alert, a good view of the fauces is obtained. Lastly, the secretions should be examined, if in any way at fault. Trouble is sometimes experienced in obtaining the urine. If necessary, a small silver catheter may be passed and a sample drawn off.

In making our diagnosis and prognosis in infancy, the following points must always be remembered as modifying disease at this period:

1. The wide diffusion of symptoms met with at the onset of an acute attack.
2. The severity of the initial symptoms often bear no proportion to the gravity of the local lesion.
3. The extremely rapid rise and fall in the temperature of the body frequently observed.
4. The rapidity with which functional mischief may pass into organic.
5. The extent to which local disease is modified by certain diatheses.

For an account of the special diseases to which the infant and new-born are liable, the reader is referred to the separate articles on these diseases.

ALEXANDER D. BLACKADER.

Infants, Artificial Feeding of.—When for any reason the infant is deprived of its mother's milk, its natural and most perfect food, the necessity of supplying it with nourishment from some other source is forced upon us. This may best be done by means of a healthy, efficient wet-nurse, if such can be obtained; but this is always a difficult matter. Very seldom can one be found who fulfils all the requirements demanded by the physician, and who is willing to submit to the careful dietary and regular mode of life necessary to insure a wholesome and even supply of breast milk to the foster child. In the great majority of cases, therefore, we have to find some artificial

nutriment which shall fulfil the important conditions of being easily digested by the infant and at the same time of supplying in due amounts all the elements required for nutrition.

Protein material the infant must have to provide for the wants of the growing tissues. Protein furnishes the elements from which the cells of the body are built up, and when it is deficient in the food, growth and development are correspondingly impaired. Especially is this true during the early months of life. Experiments on the young of animals indicate that a food containing a liberal supply of protein tends to produce larger animals, with more bone, muscle, and blood, than does a food in which the protein is deficient and the fats and carbohydrates in excess. If the food contains an excess of protein with a deficiency of fats and carbohydrates, the protein may supply the deficiency and be converted into muscular and nervous energy. But such a use of protein makes a heavy demand on the digestive and assimilative powers of the infant, and except under abnormal conditions is not to be recommended.

Next to the proteins the carbohydrates are the most important element in the infant's food and are essential to nutrition and proper metabolism, for when they are absent, or present in only small amounts symptoms of acidosis may set in. Both carbohydrates and fats when burned in the system furnish heat and supply muscular energy to the cells, but the carbohydrates when broken up in the metabolism of the body are able not only to supply sufficient oxygen for their own hydrogen, but also to aid in the oxidation of the waste products of the fat and protein molecules as they are broken down in the body. (Rachford.)

A recent writer states that the carbohydrates also supply water to the cells in such a manner that it dilutes the cell contents and reduces their osmotic pressure so as to produce a flow of nutriment into them from the more concentrated blood on their exterior. (Chapin.) Too great excess of carbohydrate material in the food may result in intestinal indigestion with diarrhea.

Fats are also important as a source of fuel and energy for the cells. Fat is the most important factor in increasing body weight; it forms an important element in the structure and nutrition of the nerve cells, and a deficiency of fat in the food seriously interferes with the nutrition of the bony structures. Its value as a source of heat is double that of the carbohydrates. Fats, however, are difficult of digestion and require to be supplied in a state of fine emulsion. Any excess of them beyond the infant's capacity of digestion may give rise to serious gastro-intestinal disturbance.

The food must also contain a due amount of mineral matter, calcium phosphate for the hardening bone, and sodium chloride and iron for the blood, daily increasing in amount. Salines are also undoubtedly of much service in the vital processes of digestion, absorption, and nutrition—processes for which water is demanded in larger amounts than required by the more adult constitution.

To supply a food which will contain all these elements in their proper amount and relative proportions and which will be easily digested and assimilated by the imperfectly developed alimentary tract of the infant, is a problem demanding much thought and care. Its importance will be appreciated when we consider the disastrous results which frequently follow attempts made in thoughtlessness and ignorance to hand-feed infants. The enormous death rate which in all countries occurs among those deprived in early days of maternal milk is appalling, while among those that survive, poor health, defective nutrition, and stunted growth plainly attest the defective nourishment supplied. As a recent writer says, it is proper or improper nutriment which makes or mars the perfection of the coming generations.

The problem, although at all times demanding careful thought, is one of very varying difficulty. If the powers of digestion are naturally strong, and especially if the infant has received the advantage of maternal nursing until the gastric and intestinal secretions have become to some degree developed the task of supplying a suitable food may be a comparatively easy one. But if the infant inherit a weak constitution with feeble powers of digestion and assimilation, still worse, if it must be bottle-fed from its birth, much difficulty will be experienced; our difficulties are still further increased during the hot season and under the unsanitary influences associated with city life. It is only within the last few years that advancing knowledge has enabled us to cope, for the most part successfully, with these various difficulties, and it must be acknowledged that for the greater part of this advance the profession is indebted to American physicians.

In the preparation of a food for infants which will comply with the requirements above stated it should be our aim to copy as closely as possible in all particulars the food which nature supplies. The substitute food must resemble maternal milk in the elements entering into its composition, in the percentage of them present in the food, and in its freedom from the presence of noxious microorganisms, and so far as may be practicable, in its digestibility by the infant stomach. To enable us to attain this result, many careful analyses have been made to find out the exact composition of mother's milk.

Rotch gives us the following as a summary of several of the more recent analyses of human milk:

AVERAGE HUMAN MILK (Rotch)

Reaction	Amphoteric or slightly alkaline.
Specific gravity	1.028 to 1.034
Water	87 to 88 per cent
Total solids	12 to 13 per cent
Fats	3 to 4 per cent
Milk-sugar	6 to 7 per cent
Proteins	1 to 2 per cent.
Total mineral matter	18 to 25 per cent

As an indication of the differences which may exist in the breast milk of different women, the following analyses, made by Harrington and quoted by Rotch, are interesting:

HUMAN BREAST-MILK ANALYSES.
(Mothers Healthy and Infants Digesting Well and Gaining Weight.)

	I	II	III	IV
Fat	5.16	4.37	3.28	3.16
Milk-sugar	5.68	6.30	5.70	7.20
Proteins	4.14	3.27	1.08	1.65
Mineral matter	0.17	0.16	0.20	0.21
Total solids	15.15	14.10	10.80	12.22
Water	84.85	85.90	89.20	87.78

In connection with these analyses it is to be noted that, although the several infants digested and throve well on their own mother's milk, when supplied with milk from another mother colic and disturbed digestion frequently resulted.

It is evident from these analyses that we have to deal with a fluid which, while containing all the elements necessary for the perfect nutrition of the growing infant, contains them in quantities which may vary considerably in each individual case, and to some extent from time to time. Of its several constituents the proteins and the fats are the most variable in their amounts, while the sugar in all is comparatively constant.

To prepare a food for the infant which will be as nearly as possible a substitute for that of its mother we naturally turn to the milk of other mammals.

Careful analyses have been made of the milk of the cow, goat, mare, and ass, and although some of them in certain respects appear to approach human milk in composition more closely than does that of cow's milk, nevertheless cow's milk is practically our only available supply; it is plentiful and cheap and with due care can be obtained fresh and pure. Goat's milk although occasionally available, possesses no advantage over cow's milk, and its peculiar odor is often very objectionable.

ANALYSES OF THE MILK OF VARIOUS ANIMALS (After König)

	Cow.	Goat.	Mare.	Ass.
Water	87.41	86.91	90.71	91.40
Caseinogen	3.01	2.87	1.24	1.23
Lactalbumin	0.75	1.19	0.75	
Fat	3.66	4.09	1.17	3.01
Sugar	4.92	4.15	5.70	6.93
Mineral matter	0.70	0.96	0.37	0.45

The following analyses of cow's milk and human breast milk as given by Rotch, shows us how closely they resemble one another in composition:

	Cow's per cent.	Woman's (directly from breast). per cent
Reaction	Slightly acid.	Amphoteric, generally alkaline.
Water	86–87	87–88
Mineral matter	0.70	0.20
Total solids	14–13	13–12
Fats	4.00	4.00
Milk-sugar	4.50	7.00
Proteins	4.00	1.5–2
Caseinogen	2.88	0.59
Lactalbumin	0.53	1.23

Although on comparing these two tables we see much similarity between the two fluids, nevertheless important points of difference may be noted. While human milk is almost always alkaline to litmus and remains so for many hours, the reaction of cow's milk is acid, owing partly to the presence in it of potassium biphosphate, and partly to the formation of small quantities of lactic acid; especially is this the case when the cow is stall-fed or the milk a few hours old. While the fat content of the two milks is virtually the same, yet the fat of cow's milk is not so digestible by the infant's stomach as that of human milk. This is due to the fact that in human milk the fat emulsion is finer and also that the fat of cow's milk contains a greater percentage of the volatile fatty acids with a smaller amount of oleic acid. The milk-sugar is notably deficient in cow's as compared with human milk. The mineral matter is more abundant in cow's milk. An analysis of the saline ingredients in the two milks shows that the potassium salts are in larger proportion in breast milk, while the lime salts are more abundant in cow's milk. Cow's milk also contains more phosphoric acid, less chlorine, less iron, and less sulphur. These differences, however, may be regarded as comparatively unimportant. The most important practical difference exists in the proteins, as shown in the way in which they react to ferments and reagents. König's analysis shows that, while in human milk the caseinogen forms one-third and the lactalbumin two-thirds of the proteins, in cow's milk the caseinogen forms four-fifths and the lactalbumin only one-fifth. As a result of this difference, it is noticed that on coagulation of the proteins of human milk by acids or rennet the curds form slowly and are small and flocculent. In the infant's stomach the calcium casein of cow's milk is promptly precipitated by the rennet ferment in the presence of a slight amount of acid into a firm clot of calcium paracasein, which later on combines with the hydrochloric acid as it is secreted, forming the hydrochlorate of paracasein with the separation of calcium. This clot is large and firm and digestible with difficulty, quite different from the soft flocculent curds of the paracasein of mother's milk.

Another important difference between the two milks still remains. While breast milk is always practically sterile, commercial cow's milk invariably contains many bacteria, from one hundred thousand to several million in each cubic centimeter, and if old it also contains the toxins evolved by their actions. It is therefore extremely important that milk to be employed in the feeding of infants should be obtained from healthy, vigorous animals, cleanly kept under the best hygienic conditions, and carefully fed and watered. The milking should be done with careful precautions to avoid contamination by impurities. The milk should at once be cooled and aërated and delivered to the consumer with as little delay as possible; prolonged transportation is to be avoided. Milk may acquire noxious properties and be rendered dangerous as a food, especially for infants, by (1) poisonous weeds taken with the food; (2) diseased conditions in the cow; (3) contamination with pathogenic organisms communicated during either milking, or storing, or transportation. Whenever the temperature of milk is allowed to rise above 7° C. (45° F.), it becomes an excellent culture medium for the growth and development of the many forms of bacteria which, even with our most careful precautions, are always present to a greater or lesser extent. Milk containing microorganisms in excess of one hundred thousand per cubic centimeter must be regarded as unfit for infant feeding. Certified milk in cities, always the most desirable milk for use in an infant's food, should have a bacterial content not above 10,000 to the cubic centimeter.

Cow's milk also varies considerably in its percentages according to the special breed supplying it, according to the character of the food on which the animals are fed, and the amount of exercise permitted.

Obtained with the above precautions, we have in pure cow's milk a food which, compared with breast milk, contains an equal amount of fat, an excess of indigestible proteins, an insufficiency of sugar, and an excess of saline matter; our efforts must therefore be directed so to modify its composition and the character of its proteins as to render it suitable and digestible by the young infant.

Many plans have at various times been recommended. Simple dilution lessens the amount of the proteins, and to a slight extent renders the curd formed by them less dense. It reduces, however, the fats and sugars much below the amount demanded by the infant organism. Keller has also shown us that with a low percentage of carbohydrates in the food there is a very low retention percentage of nitrogen in the system, and general nutrition is defective. Mere dilution, therefore, is not to be commended.

Lehmann many years ago pointed out the effect of the addition of an alkali in rendering the curd produced by rennet less dense. He stated that human milk when acid yields a much thicker coagulum than when alkaline, and cow's milk when alkaline a much looser coagulum than when acid. The alkalies generally employed for this purpose are lime water in the proportion of one to ten or twenty of milk and sodium bicarbonate to the extent of five or ten grains to the pint of milk. This alkalinizing the milk is of value only in preventing the rapid action of the acid and rennet on the milk in the infant's stomach. The caseinogen or paracasein as it is frequently termed, combines with both acids and alkalies. When rennet is added to a

neutral milk in an acid medium clotting takes place rapidly, but if the milk be distinctly alkaline the acidity of the medium is neutralized, and coagulation takes place slowly as the acidity is regained. If milk is rendered so alkaline that the fluids of the stomach cannot acidify it, much of it may be passed into the duodenum without coagulation, there to be acted upon by the pancreatic juice. A few years ago Poynton of London advocated the use of sodium citrate one or two grains to the ounce of milk as the best means of preventing this coagulation. Sodium caseinogenate is formed with the liberation of citric acid, and this unites with the calcium forming calcium citrate which is said to be absorbed. This sodium caseinogenate does not coagulate till acted upon by the hydrochloric acid, an action which takes place only slowly.

Another method of much value in preventing the formation of large firm curds is dilution of the milk with a thin gruel, which by its physical consistence is able to diminish the density of the coagulum. This method is an old one, as we read that Van Swieten, in the fifteenth century, used decoctions of wheat or barley for this purpose; but its utility has of late years been very strongly urged by Dr. Jacobi and Dr. Chapin. That it has a distinct value has also been proved by Professor Leeds, who, in a series of careful experiments, showed that the coagulum which forms in a thin gruel encloses much material which, by honeycombing the curd, acts as an attenuant. Coagulation also takes place more slowly, a very positive advantage, as it affords the digestive fluids a better opportunity for action. Many substances have been used for this purpose. Dr. Jacobi recommends well-boiled decoctions of barley or oatmeal. He says "I have always preferred barley when an article for steady diet was to be recommended, for the reason that oatmeal, on account of its containing fat and mucin, tends to relax the intestines more than barley meal. Otherwise the chemical composition of both is so nearly alike that it would make but little difference upon which the choice would fall. Gum arabic and gelatin may also be employed in the case of very young infants.

Dr. S. C. Busey urged the advantage occasionally obtained by substituting rice water, prepared in a similar way, for the barley gruel, and says that he has often witnessed its beneficial effects in cases of diarrhea and vomiting.

The disadvantage of all such diluents, for young infants, is that they introduce a material quite foreign to milk, and one with which their digestive powers are unfit to grapple until their salivary and pancreatic secretions are more developed. For such, therefore, the addition of a gruel to milk while serving as an attenuant of the casein may give rise to symptoms of indigestion. Dr. Jacobi, however, considers that a small amount of starch may be digested at the very earliest age. It is important, nevertheless, in the case of infants under six months of age that the percentage of starchy matter should be small, and that it should be very thoroughly cooked. Recently Chapin has strongly advocated the use of a gruel made from wheat, barley, or oatmeal, the starch of which has been predigested or dextrinized by the addition of some form of diastase. His directions are as follows: "A heaping tablespoonful of flour made from one of these cereals is boiled with a pint and a half of water for fifteen minutes. It is then removed from the stove and set in cold water till cooled to about 120° F., when a teaspoonful of some good preparation of diastase is added; this dextrinizes the starches and renders the gruel thin, watery, and easily assimilated by the infant, though it still remains an efficient attenuant of the curd."

In addition to these methods of preventing the too firm coagulation of the casein in the infant's stomach it is always practicable to predigest the proteins of the milk by means of one of the numerous preparations of pancreas, and thus to do away more or less completely with the formation of the curd. In using one of these preparations the following method is recommended: The milk modification in amount sufficient for the infant's feeding is taken from the cool chamber in which it is kept and heated to a temperature between 110° F. and 120° F. The peptonizing powder is then added and the heat maintained for ten or fifteen minutes. The food should then be cooled to a temperature of 98° F. and at once fed to the infant. A peptogenic milk powder has also been prepared, containing pancreatin and bicarbonate of sodium, along with milk-sugar. When the food is wanted the powder is added to a mixture of milk, cream, and water, and the whole is kept at blood heat for some minutes. When properly prepared the resulting milk should closely resemble mother's milk in the reaction of its proteins and its composition.

In practical use, however, predigestion of milk does not appear to have given as excellent results as was at first anticipated. It is a method that may be employed occasionally with benefit especially in cases of severe exhaustion accompanying or following acute disease, and in some forms of gastric disorder associated with a temporary inability to digest the proteins in milk. The degree to which the predigestion must be carried will depend on the power of protein digestion present in the infant, but as soon as possible the time of predigesting the milk and therefore the amount of peptonization it undergoes should gradually be lessened; predigestion of food for any lengthened period appears to be opposed to the teachings of physiology.

In all these methods, however, with the necessary dilution of the milk, the quantity of fats and sugar falls far below the requirements of the growing infant organism and requires to be increased. In reference to the deficiency in the fat, Dr. Jacobi puts in a strong plea against allowing any excess to be present in our mixtures. He says that the infant does not digest all the fat contained even in its mother's milk, and we ought not therefore to increase the amount of the indigestible ingesta by adding to them. In opposition to this, Dr. Rotch very pertinently remarks: "We have no right to conclude from the fact that a certain amount of surplus fat is found in the napkins, that only a small per cent. is sufficient for nutrition. It is more probable that nature introduces a certain percentage of fat in human milk with a purpose which can only be accomplished by that percentage, and it will be an error on our part not to conform to our standard." My own experience confirms that of many others, that average infants can digest from two to four per cent. of fat; more than this is liable to give rise to gastric disturbance, and may induce vomiting or diarrhea; a prolonged deficiency in the fat, however, will interfere distinctly with the infant's nutrition.

To make good the deficiency in the fat we must rely either on creams of a known percentage or make use of Chapin's method of obtaining top milk. The serious drawback to the employment of creams of various strengths is the difficulty of obtaining them fresh and sterile. Cream obtained by means of a centrifugal separator contains from twenty to thirty per cent. of fat with a slightly lessened percentage of proteins and carbohydrates; but cream thus obtained is in the opinion of many physicians more indigestible than "gravity" cream (*i.e.* cream obtained by allowing the milk to stand), as frequently in centrifugal cream many of the fat globules have coalesced. With gravity cream it is undesirable that the milk from which it is obtained be more than twelve hours old. The most convenient method to obtain such a cream is to allow fresh milk containing about four per cent. fat to stand in a tall glass jar on ice for a certain

number of hours. After standing six hours almost all the cream will have risen and if carefully removed will contain about sixteen per cent. of fat. In this top milk the proteins and carbohydrates may be regarded as approximately 3.5 per cent. By employing such gravity cream or top milk in our dilutions we may raise the amount of fat content in our milk modification to any desired standard.

A milk modification containing fresh milk sixteen ounces, gravity cream (16 per cent.) eight ounces, barley gruel sixteen ounces, will give us a food containing 4 per cent. fat, nearly 2 per cent. protein, and 2.5 per cent. carbohydrate.

Chapin recommends that a certain portion of the top of the milk taken from the quart bottles as ordinarily delivered at the door in the morning be employed for the preparation of our milk modifications. The milk should be the cleanest obtainable from a herd of well-selected cows. The bottles as delivered should be allowed to stand for six hours at a temperature not exceeding 45–50° F. The desired amount may then either be removed from the top by means of a Chapin dipper, or the milk may be siphoned from the bottom of the bottle till the requisite amount remains behind in the bottle. Chapin gives the following assays of the amount of fat in the various portions of top milk obtained in this way:

The top 6 ounces contain	nearly	17 per cent. fat
The top 9 ounces contain	"	11.5 per cent. fat
The top 12 ounces contain	"	9 per cent. fat.
The top 16 ounces contain	"	7 per cent. fat.
The top 24 ounces contain	"	5 per cent. fat
When the whole 32 ounces contain	"	4 per cent. fat

One may in this way obtain a superfatted milk which on proper dilution will give us the desired percentages in both proteins and fats. Thus if we take a 12 per cent. top milk and add to it three parts of diluent, we shall obtain a modification containing three per cent. fat, nearly one per cent. protein, and one per cent. milk sugar; or if we take a seven per cent. top milk and dilute with an equal quantity of diluent we obtain a modification containing 3.5 per cent. fat, 1.75 protein, and 1.75 carbohydrate.

In correcting the deficiency of the carbohydrates the majority of pediatrists prefer to use milk-sugar, the form found in the milk of all mammals. Jacobi, however, prefers cane sugar, considering that the identity of the lactose in human and cow's milk is very doubtful. He also thinks that as milk-sugar readily undergoes the lactic-acid fermentation, any excess of it tends to increase the elimination of calcium phosphate and thus favors the development of rickets. On the other hand, Vaughan considers that milk sugar is more readily assimilated by infants, and Escherich states that milk-sugar when acted on by the *Bacillus lactis aerogenes* develops lactic acid, which tends to prevent the development of many noxious forms of bacteria.

On the whole milk-sugar is generally a satisfactory form in which we can supply the deficiency of carbohydrates. Added in the proportion of one ounce to twenty of the milk modification it supplies an additional five per cent. of carbohydrate. Cane sugar may be used occasionally, but because of its sweetness must be employed in much smaller amount, and for this reason scarcely supplies sufficient for the carbohydrate demands of the system. Both milk and cane sugar may give rise to intestinal fermentation.

Attention has been called during recent years to maltose as a useful substitute for milk-sugar when the latter shows a tendency to produce intestinal fermentation. It is said to be more rapidly and more completely absorbed and more easily assimilated than either milk or cane sugar and may be employed in the same or even larger amounts.

By means of these methods we are enabled so to modify cow's milk that it fairly represents in its elemental ingredients and in its digestibility human breast milk.

The profession is very deeply indebted to the late Dr. Rotch of Boston, who first introduced the method of thinking and making milk modifications in exact percentages of proteins, fats and sugars. By this plan scientific accuracy in our modifications was substituted for much indefiniteness. We were thus not only enabled to prepare a food to resemble closely breast milk in its physical characters and chemical composition, but also to vary its composition with accuracy, and thus render it suitable to the special demands of individual infants. On this subject Rotch says: "While in quite a number of cases rather gross changes in the percentages of the different elements of the milk may be sufficient for the range of the individual digestion and for the nutrition of the special case, yet in a large number of infants whose vitality is low and digestive powers feeble, good results can only be obtained by gradual and minute changes in the percentage combinations of the milk elements."

For such it is desirable that we have the power of making use of modifications as precise as our knowledge at the present time renders possible. Even slight changes in the percentages of the fat, the sugar, and the proteins may be of real value in the management of the digestion and nutrition of the infant.

The substitute food must be adapted, not only to the infant's stage of development, but also to its individual capability of digesting the several elements of its food. To enable us to obtain these varying combinations of the milk elements and to have them regularly and exactly supplied to our patients, Dr. Rotch originated *milk laboratories*, which have been established in many of our large cities, equipped with special machinery and placed under the management of men specially trained for the work. The milk employed in these laboratories is obtained with the strictest precautions to insure its absolute cleanliness, from vigorous cows of a carefully selected breed. The feeding and housing of these cows are under careful supervision, and are so arranged that milk of a known and almost uniform composition is obtained. From this milk, by means of the centrifugal separator, the fat is separated and a cream of uniform percentage obtained. The milk remaining is almost fat-free, and is found by frequent analysis to contain a fairly uniform percentage of proteins, milk-sugar, and mineral matter. It is now a simple matter to dilute, with distilled water, either the cream or fat-free milk, so as to obtain the requisite amount of protein; milk-sugar is added to make up the defective percentage in that element, and cream supplies the exact quantity of fat. With a knowledge of the exact percentages in the cream and fat-free milk, a simple calculation suffices to obtain whatever percentage of the elements the physician may prescribe. The amount of mineral matter may be disregarded, as the dilution required by the protein practically makes a sufficient reduction in its amount.

The milk thus modified may be sterilized, at the temperature deemed necessary by the physician, and placed in bottles, each containing the amount ordered for one feeding of the infant; the total number of feedings for the day, securely packed in a small basket, are delivered each morning to the consumer.

The following is an illustration of the method in which this modified milk may be ordered by the physician:

Fat	[illegible]	No. of [illegible]	[illegible]
Milk-sugar	[illegible]	[illegible]	[illegible]
Albumin	[illegible]	[illegible]	[illegible]
Cream	[illegible]	Infant	[illegible]
Lactalbumin	[illegible]	Infant's weight	[illegible]
Mineral matter	[illegible]	Alkalinity	5 per cent.
		Pasteurize	[illegible]

Although this was a very great advance on our

previous crude methods of modifying cow's milk, nevertheless instances occur in which even the small percentage of casein present in the diluted milk overtaxes the feeble digestive powers of the infant. In these Rotch recommended that the amount of proteins be reduced at the first to a minimum, and then gradually, as the infant's digestion becomes stronger, this amount may be increased until the quantity necessary for perfect nutrition is attained. Much difficulty may be experienced in making this increase as rapidly as the demands of nutrition appear to require, and recourse may be had to the addition of one of the cereal gruels, which in many instances appear to render the casein more digestible.

More recently Dr. Rotch proposed to get rid of the caseinogen, in young infants such a frequent source of trouble, by the use of a whey obtained from fresh cow's milk by means of rennet. Thus prepared, whey contains all the lactalbumin, sugar, and mineral matter, but none of the caseinogen and almost none of the fat. Its average composition, as compared with that of whole milk, is as follows:

	Whole milk	Whey.
Fat	4.00	0.32
Sugar...	4.50	4.79
Proteins	4.00	0.85

Dr. Rotch's directions for its preparation are as follows: For each pint of whey required take one quart of whole fresh milk, or fat-free milk, heated to 37.7° C., and add 8 c.c. of essence of pepsin or an equivalent of one of the liquid preparations of rennet. This will precipitate the casein in the form of curds, which are afterward to be broken up with a fork; the fluid remaining is then strained through several thicknesses of boiled cheese cloth and slowly cooled to a temperature of 10° C. It must be kept on ice till required. If the whey is to be mixed with cream, the whey must first be heated to 65.5° C., in order to kill the rennet enzyme. Whey mixtures should not be heated above 68.3° C., if one wishes to keep safely under the coagulation point of the lactalbumin. With whey as a basis to which cream and milk-sugar in requisite amounts may be added, a modified milk may be prepared which will exactly correspond in its percentages and reactions to that of breast milk. This modification has been found of value during the early months of infancy, while the digestive powers of the infant are still feeble.

While milk laboratories are not only a great convenience to the physician in the preparation of these various combinations of percentages, but also of value in permitting such combinations to be made with greater exactness than by any method of home modification, nevertheless the advantages of a milk laboratory are not everywhere to be obtained, and in the opinion of many physicians modifications of milk can be carried out at home with sufficient exactness to fulfil the wants of the great majority of infants. To succeed, however, the physician must be capable of giving exact instructions as to the details of the process.

In undertaking home modification it is extremely important to secure a supply of good fresh milk, and one in which the percentage of the fat is known and maintained by careful feeding at a fairly uniform amount. It is to be remembered that the amounts of fat will vary very much according to the particular breed of cows supplying the milk. In an average mixed herd the fat generally amounts to about four per cent.; in a herd of Jersey or Alderney cattle it may amount to five or six per cent.

These rich milks generally disagree with the infant's stomach. In the preparation of our modifications for infant feeding many physicians recommend whole fresh milk as the simplest material to be employed. But this, when diluted sufficiently to secure easy protein digestion, leaves us with a decided deficiency in the fats. In warm weather, and in some infants who digest fat with difficulty, this relative deficiency may suit the infant's digestion better than a modification containing a higher percentage of fat. For average infants, with fair digestive powers, however, it is not wise to let the percentage of fat fall below two or exceed four. To obtain these percentages in a diluted milk we must either add cream to our dilution or employ top milk. Cream, as we have before stated, is liable to be uncertain of uniformity in its composition, is frequently old and laden with bacteria, or if obtained from the separator has its natural emulsion destroyed. Therefore, as a rule, superfatted milk or top milk is much to be preferred. The table which follows will show the method by which this top milk may be employed in making modifications of any desired strength. The diluent may be either water or some cereal gruel. When we use the latter it must be remembered that gruels contain a certain amount of both protein and carbohydrate and therefore have a food value which is not negligible. A gruel made from

Suggested Modifications of Cow's Milk Suitable for Healthy Infants.

(Modified from Chapin.)

Age.	Amount of food to be prepared.	Number and size of feedings for twenty-four hours.	Intervals of feeding.	How to make food		Add			Percentage composition.		
				Remove from top of quart bottle milk.	Of this use.	Water	Gruel.	Sugar.	Protein.	Fat.	Carbohydrate.
One week	20 oz	10 of 1½ oz	2 hours	top 9 oz	2½ oz	17½ oz.		1 oz.	0.40	1.5	5.50
Two to four weeks	28 oz.	9 of 2 oz.	2 hours twice during night.	top 12 oz.	7 oz	21 oz.		1½ oz.	0.80	2.25	6.00
Two months	32 oz	7 of 2½ 3½ oz.	2½ hours once during night.	top 16 oz.	12 oz.	20 oz.		1¾ oz	1.20	2.60	6.5
Three months	36 oz.	7 of 4 oz.	3 hours once at night.	top 16 oz.	16 oz.	16 oz.	16 oz.	1¾ oz.	1.4	3.00	7.0
Four to six months	40 oz.	6 of 5–7 oz.	3 hours once at night.	top 20 oz.	20 oz.	10 oz.	10 oz.	1½ oz.	1.70	3.00	7.0
Seven to nine months.	48 oz.	5 of 8–9 oz.	3½ hours	top 24 oz.	30 oz.		18 oz.	1½ oz	2.00	3.00	7.0
Ten to twelve months..	48 oz.	5 of 9 oz.	4 hours	whole milk.	36 oz.		12 oz.	1½ oz.	3.40	3.00	7.0
After twelve months	.....	10 oz.	4 hours	whole milk.					3.5	4.00	4.50

one ounce of cereal to the quart of water contains approximately twenty-five per cent. of protein and two per cent. of carbohydrate; therefore when a gruel is employed a smaller amount of milk sugar is required.

In the case of healthy children a modification of a good quality of milk prepared according to the above formula will generally prove satisfactory. In deciding upon the modification to be used the weight of the infant must be considered as well as the age. If above the average weight it will require a stronger food, while if below weight a weaker food than is indicated in the schedule. If there are no digestive disturbances but the infant does not appear satisfied and fails to gain satisfactorily, the food should be strengthened or the amount increased. If vomiting of sour and rancid smelling material occur an hour or more after feeding the amount of fat in the food should be promptly reduced, especially if such vomiting is associated with an acrid diarrhea. In extreme cases the fat element must be omitted altogether, using only skim milk in the preparation of the food. If the baby's stools are sour and watery the quantity of sugar in the food should be reduced. If the infant suffers from colic and passes many curds in its stools, an attempt may be made to prevent the curds by the addition of one grain of sodium citrate to the ounce of milk. If this fail the food may be peptonized for ten or fifteen minutes before it is fed to the infant. If the infant is doing well but is constipated, oatmeal gruel should be used as a diluent and the amount of fat content in the food may be gradually increased. Sudden changes in the strength of the food and the amount given at a time should be avoided. It is always wise to advance very gradually from the weaker to the stronger modifications.

When the infant is eight months old, a little stronger and more solid food may be given. Preceding the bottle one or two tablespoonfuls of some cereal may be fed by a spoon (oatmeal, cream of wheat, or farina sweetened and to which a little fresh milk has been added), after which the infant may be allowed to finish its meal with what it will take of its milk modification. At the ninth month a little meat juice or beef tea may be given at its mid-day feeding, and when the child is a year old a raw egg may be broken into the beef tea, or a lightly coddled egg with bread crumbs may be allowed. A little stale bread and butter may also be given at one or two of his meals.

The German school has for many years insisted on the value of comparing the caloric value of any artificial food with which an infant is being fed with a standard estimated from the caloric value of mother's milk as consumed by a normal infant of the same age and weight. According to calculations made by several investigators infants consume daily during the first three months an amount of milk equal to forty-five calories per pound of body weight; during the next quarter about forty-three calories; during the third quarter about thirty-eight calories, and during the last quarter of the first year about thirty-four calories. We are told accordingly that an infant's food should have at least a value of forty calories for every pound of the infant's body weight, this amount to be slightly increased for infants under six months of age.

To estimate the number of calories in any food multiply the caloric value of an ounce of each ingredient entering into the composition of the food by the number of ounces contained in the total day's feeding and add the products together; the total will represent the caloric value of the food:

1 ounce of skimmed milk =	13 calories.
1 ounce whole milk =	21 calories.
1 ounce 7 per cent. top milk =	31 calories.
1 ounce 9 per cent. =	36 calories.
1 ounce 16 per cent. =	54 calories.
1 ounce of carbohydrate =	120 calories.

The only value of this caloric estimation is to prevent over- or underfeeding; it cannot be regarded as in any measure able to take the place of percentage feeding.

Sterilization.—In the infant the digestion of milk is for the most part accomplished in the small intestine. There is no long delay in the stomach with prolonged exposure to an acid and therefore antiseptic medium, as in the adult, but the milk after an imperfect curdling is quickly passed on to the duodenum. Gastric digestion, the safeguard in older children and in adults against the entrance of disturbing microorganisms into the alimentary tract, affords in infants but a feeble barrier. For that reason one of the more important conditions in the infant's food is that it be sterile. This is the more necessary should the infant's food involve a longer time in its digestion than breast milk.

It is, therefore, extremely desirable that the milk employed in infant feeding be obtained with such careful precautions as to render it practically free from extraneous bacteria. It is not always our good fortune, however, to be able to obtain such with the regularity necessary for the daily preparation of an infant's food, and when our supply cannot be depended upon it appears the lesser of two evils to have the milk pasteurized at the lowest efficient temperature—that is, 60°–68° C. (140°–155° F.). Milk sterilized at over 70° C. is altered to an extent varying according to the elevation of the temperature employed and the duration of the exposure in the following respects: (1) its proteins are modified and rendered less digestible; our knowledge on this subject, however, is still indefinite and dependent chiefly on clinical experience; (2) the combination of its saline ingredients with the proteins is to some extent broken up and the salts assume a condition in which they are less readily absorbed; (3) natural ferments, whose presence in milk may with much probability be inferred and which may materially assist its digestion in the infant's stomach, are destroyed; and (4) an alteration takes place in the emulsion normal to milk, which may also have distinct effect in lessening its digestibility by the infant. For these reasons, it is important that the milk for infant feeding should not be sterilized at too high a temperature. After pasteurization it should be kept at a continuously low temperature; and it is to be remembered that the employment of sterilized milk which has been kept for many days is not free from danger.

Condensed Milk.—Fresh evaporated milk (milk condensed with the addition of cane sugar) may be of some service when pure fresh milk is impossible to obtain. The heat employed during the earlier stages of its preparation has rendered it sterile, and it may under favorable conditions keep after the can is opened for two or three days. For use in infant feeding it should be diluted with four or five parts of water, or cereal gruel, and sufficient lactose or maltose added to make up the requisite percentage of carbohydrate. Kerley states that many infants of very weak digestion will thrive on evaporated milk when the modifications of cow's milk fail. The ordinary canned condensed milk has the disadvantage of containing a large amount of cane sugar and a very small amount of fat. When diluted with ten or twelve parts of water, as it usually is, the mixture is altogether too weak of itself to serve efficiently as a permanent diet. For children over six months of age the dilution should be made with a strong cereal gruel. Such a combination may tide an infant with impaired digestion and under unfavorable conditions, over two or three of the hot summer months. As soon as possible fresh top milk should be added in gradually increasing amounts to strengthen its nutritive powers. The use of condensed milk for any prolonged period is much to be deprecated. Holt states that he has not yet seen an infant who was reared exclusively on condensed milk who did not show more or less evidence of rickets.

Composition of Various Modifications of Milk and Their Derivatives

	[illegible]	Diluted with 5 parts water.	Con- [illegible]	Diluted with 9 parts water.	Diluted with 12 parts water
Fat	8.3	1.4	6.94	0.99	0.59
Protein	7.1	1.2	8.43	1.20	0.44
Sugar, [illegible]		.	40.44	5.77	3.11
[illegible]	[illegible]	1.7	10.25	1.19	0.79
Salts	1.43	0.2	1.39	0.2	0.12
Water	73.07	95.7	31.30	90.05	96.46

Gärtner's Fettmilch.—In Germany during the last few years a modification of cow's milk has been prepared by Gärtner, as follows: Into the drum of a large centrifuge a mixture of milk and sterile water, at a temperature of from 10°–15° C., is allowed to run, care being taken that the milk used is obtained in the most cleanly manner from healthy cows properly fed. The drum of the centrifuge is made to revolve rapidly, driving the fat, as it is only in suspension, toward the center of the drum, while the sugar, casein, and salts, which are in solution, remain uniformly distributed. Two tubes which carry off the milk enter the drum, one near the center and one at the periphery. By arranging how near to the center the inner tube opens, and the speed at which the drum revolves, milk containing fat in various percentages may be drawn off. As ordinarily set the milk drawn off near the center has the same amount of fat as mother's milk, and is only deficient in sugar. Its composition, which is fairly constant, is fat 3, sugar 2.5, proteins, 1.76. By adding a certain proportion of milk-sugar, milk closely resembling breast milk in composition is obtained.

This plan has also the advantage that any dirt present in milk and most of the bacteria are thrown off toward the periphery, thus leaving the central portion free. It is also claimed that the cream is not so completely separated from the milk as in Rotch's plan, but remains in a more perfect emulsion. Thus prepared the Fettmilch resembles ordinary milk in appearance and has an agreeable taste. Before using it as an infant's food it is recommended that it should be sterilized. Escherich has laid down the following rules for the amount and frequency with which this food may be given:

During each 24 hours children of 2 weeks require 16 ounces in 9 meals; from 2 to 4 weeks, 25 ounces in 8 meals; from 4 to 8 weeks, 33 ounces in 8 meals; from 3 to 4 months, 42 ounces in 8 meals; from 5 to 6 months, 50 ounces in 7 meals.

The employment of this milk is strongly recommended by many eminent German authorities.

Buttermilk.—In some cases of infantile atrophy and gastrointestinal disease buttermilk may be of service. It has long been successfully used in Holland. Ordinary buttermilk made from cream or milk that has soured naturally has an average composition of one per cent. of fat, four per cent. of sugar, and three per cent. of protein. A better preparation is made, however, by adding one of the lactic acid ferments on the market to fresh whole milk. Buttermilk obtained in either of these ways contains enormous numbers of lactic acid bacteria which when introduced into the intestine may have a definite value in preventing the development of more harmful species.

A modification of buttermilk very frequently employed and readily taken by the infant is prepared as follows: To one quart of buttermilk is added one ounce of wheat flour (four level tablespoonfuls) and one level tablespoonful of cane sugar. This mixture is with constant vigorous stirring slowly brought to the boiling point and kept there for twenty minutes and then allowed to cool. Buttermilk thus prepared has a high protein and carbohydrate and a very low fat percentage. The casein is very finely divided and exists as lactate of casein uncoagulable by the rennet, but readily digested by the intestinal ferments. It may be further modified by dilution with water.

Albumin Milk.—Finkelstein's albumin milk has for the past few years been very strongly recommended for the relief of the conditions attributed to sugar intoxication, and in acute intestinal diseases. It is prepared as follows: One junket tablet is added to a quart of milk at a temperature of 105° F. and allowed to stand until the milk coagulates—about one hour. The curd is then thoroughly beaten with a fork to break it into fine particles and it is then placed in a bag of fine cheesecloth and allowed to drip for an hour; it is then washed carefully with boiled water and afterward put through a strainer twice. To the curd thus prepared one pint of boiled buttermilk is added and the whole again passed through a strainer until the casein is so finely broken up that it resembles in appearance ordinary milk. Water should be added to make the whole measure one quart. Thus prepared its composition is stated to be, protein 3, fat 2, sugar 1.5. Kerley strongly recommends the use of it in acute intestinal disease. After a large dose of castor oil, followed by the administration of plain barley water for twenty-four or forty-eight hours, the infant is placed on this albumin milk quite regardless of the character of the stools. From one to four ounces are given at a feeding; when small quantities are given each feeding is supplemented by as much barley water as the child will take. Kerley claims his results have been uniformly satisfactory, but recommends that as soon as the condition of the intestinal trouble will permit, the infant should be placed on a fresh milk modification.

Patented Food.—When for any reason failure has attended the attempt to feed an infant on cow's milk more or less modified, there is with many parents a strong inclination to resort to one of the numerous patent artificial foods placed before the public by interested agents who loudly vaunt their own special preparations as the exact analogue of mother's milk and the only food calculated to help the infant in its dire distress. We cannot deny that many of these foods have met with much popular favor and that some of them have proved of occasional service. It seems desirable, therefore, that the physician should have a knowledge of their physical properties and their composition further than the meager and often incorrect statements contained in their advertisements. In almost all these foods dependence is put, for the greater part of the nourishment supplied, on milk which is either added by the user or previously introduced by the manufacturer. They are therefore to be regarded as modifications of cow's milk; a fact which may explain the apparently successful results which sometimes attend their employment.

With the exception of those which contain the milk in a condensed form, all, if administered alone, show a great deficiency in many of the most important ingredients of an infant food, and especially in the element of fat. It is to be noted also that they are secret preparations, over which we as physicians can exercise no supervision or control in regard to the quality of the material or to the amount of care used in their manufacture; that analyses made by many able chemists have given very variable results, often differing widely from the manufacturer's published composition; that they are liable to be old and musty; and that for the poorer classes they are an expensive food. These foods may be grouped into four classes. The first class contains the farinaceous foods prepared from the flour of one or more of the cereals, with the starch to some extent modified by baking. Among the best known of this class are the following: Imperial Granum, Blair's Wheat, Hubbell's Wheat, Hard's Food, Ridge's Food, and Robinson's Patent Barley.

In a second class are placed all those in which the starch is almost entirely converted into a mixture of dextrin, dextrose, and maltose, with a small amount of cane sugar. These foods have in some instances a distinctly laxative action, and may sometimes be of service when the infant is of a constipated habit. They are not complete without the addition of milk. Mellin's food is the best example of this class.

A third class comprises those foods to which the milk has already been added during the process of manufacture. All of them contain starch in considerable quantities, to a small extent only converted into dextrose. Their mode of preparation insures more or less complete sterilization of the milk, and this may sometimes be an advantage during the summer season. Nestlé's food and Horlick's malted milk are examples of this class.

A fourth class may be made of foods recently introduced in which a certain amount of predigestion of the milk takes place in the course of the preparation of the food. Peptogenic milk powder the Allenbury foods, and Benger's food may be quoted as examples of this class.

The following table of Chittenden's analyses represents the composition of several of these foods when prepared as directed for the infant's use:

These Analyses Represent the Composition of Some of the Infant Foods as Prepared According to the Directions for Infants Six Months of Age.

	Mother's milk	Malted milk	Nestlé's milk food	Imperial Granum	Mellin's Food	Peptogenic milk powder
Total solid matter...	13.26	7.43	7.24	8.47	12.00	13.97
Water	86.73	92.47	92.76	91.53	88.00	86.03
Inorganic salts . . .	0.20	0.29	0.13	0.34	0.47	0.26
Soluble albuminoids..	2.00	1.15	0.36	1.67	2.62	2.09
Insoluble albuminoids.	0	trace	0.45	0.48	0	0
Fat...	4.13	0.68	0.36	1.54	2.89	4.38
Milk sugar. . .	6.93	1.18	0.84	2.71	6.25	7.26
Cane sugar . . .	0	0	2.57	0	0	0
Maltose . . .	0	3.28	trace	trace	2.20	0
Dextrose . . .	0	0.92	0.44	0.58	0.53	0
Starch	0	0	1.99	1.22	0	0

Amount to be given.—Not only are the character and composition of the food itself of importance, but the amount to be given and the times of giving it demand the physician's careful attention. As Biedert remarks: the infant has no instinct which guards against overfeeding. Even breast-fed children are apt to drink too much, but those artificially fed have a greater tendency to excess, since in general they obtain their food more quickly and with less exertion on their part. The truth should be carefully impressed upon mother and nurse, that a bottle-fed infant thrives best upon the minimum amount of food necessary for good development; excess tends to interfere with digestion, and thus unfavorably affects nutrition.

Illustrations of Above Rule to Serve as Guides for Especially Difficult Cases.

Initial weight	Early days	Each feeding. At 15 days.	At 30 days
3,000 gm.... (6.6 lb.)	30 gm. (about ℥i).	30+15=45 gm. (about ℥ iss.).	30+30=60 gm. (about ℥ ij)
4,500 gm (9.9 lb.)	45 gm. (about ℥ iss).	45+15=60 gm. (about ℥ ij)	45+30=75 gm. (about ℥ iss).
6,000 gm (13.2 lb.)	60 gm. (about ℥ ij)	60+15=75 gm. (about ℥ iss.)	60+30=90 gm (about ℥ iij)

Dr. Rotch quotes the results of Smitkan's investigations at the Children's Hospital in St. Petersburg, to determine the amount that should be given during the first few weeks of life. He finds that the greater the weight the greater is the gastric capacity, and says that one one-hundredth of the initial weight of the infant should be taken as the starting figure for each meal, and to this should be added one gram for each day of life.

The following table (from Rotch) will afford an indication, for an average infant, of the amount to be given at each feeding and the number of feedings which should take place in the twenty-four hours:

General Rules for Feeding During the First Year (Rotch).

The day feedings are supposed to begin at 6 A. M. and cease at 10 P. M.

Age	Intervals in hours	Number of feedings in 24 hours	Number of night feedings	Amount at each feeding	Total amount in 24 hours, c.c.
One week	2	10	1	1	10
Two weeks	2	10	1	1½	15
Four weeks	2	9	1	2½	22½
Six weeks	2½	8	1	3	24
Eight weeks	2½	8	1	3½	26
Three months..	2½	7	0	4	28
Four months	2½	7	0	4½	31½
Five months...	3	6	0	5	30
Six months	3	6	0	5½	33
Seven months..	3	6	0	5½	33½
Eight months..	3	6	0	7	42
Nine months	3	6	0	7	42
Ten months....	3	5	0	8½	42½
Eleven months.	3	5	0	8¾	43¾
Twelve months	3	5	0	9	45

Very rarely, in the cases of immature and very sickly babies and of infants with cleft palate, the ordinary feeding-bottle is ineffectual, owing to the infants not having power to suck. Feeding by spoon is slow and wearisome to the infant. In these cases, Jacobi recommends the use of Soltmann's *biberon pompe*. In this feeding-bottle simple pressure on the mouthpiece, either by the lips or gums of the infant, or on the expanded portion of the tube outside the bottle by the fingers of the nurse, will cause the food to escape from the bottle. Jacobi says that in many cases it has done good service. Rotch recommends the use of a glass cylinder, graduated and capable of holding nine drachms. One end gradually tapers till a small nipple can be fitted on to it; the upper end is covered by a compressible rubber bulb. By gentle compression of this bulb the food may be slowly forced into the infant's throat without any effort on its part.

This method appears to be specially desirable in the case of a weak infant, as it involves no loss of strength.

Gavage.—Some years ago Tarnier, of Paris, advocated the method of gavage in infants prematurely born or in such as are congenitally weak. The apparatus necessary for the purpose is very simple: a soft-rubber catheter, No. 14 or 15 French, or a piece of gutta-percha tubing with a small glass receptacle, of sufficient size to hold the amount of milk to be administered, attached to the distal end. The child is placed on the knee of the nurse with its head slightly raised. The tube is moistened with milk and introduced at the base of the tongue and then very gently, forced down the esophagus to a distance of fifteen centimeters. The sound is then pinched between the two fingers and the food is introduced into the receptacle. On relaxing the fingers and raising the receptacle the food flows gently into the stomach. Care must be

taken to remove the tube gently and quickly, the infant must then be replaced in its warm cradle or couveuse. To the weakest infants eight grams of food are given every hour. In spite of this feeding the infant frequently loses weight for the first few days, but soon begins to gain steadily. Tarnier claims to have achieved marvelous results by this method.

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Infantilism.—This is defined by Hastings Gilford as a *conspicuous delay or arrest of development* and is to be distinguished from dwarfism which is a serious delay or arrest of growth. There is, on the one hand, a racial or an ethnic infantilism as illustrated by the forest dwarfs of Central Africa, and there is, on the other hand, an individual or developmental infantilism which may be again subdivided into the infantilism either of cells, of organs, or of the body as a whole. The last may be the result of two factors: an inherent tendency to variation and some external cause such as the action of disease toxins; or it may be idiopathic or spontaneous, the expression of a mutation, sudden in its appearance and often hereditary. One may therefore speak of symptomatic general infantilism and of infantilism as a fluctuation. The former is subdivided into (1) toxic, (2) correlative, and (3) deprivational infantilism. Toxic infantilism is exemplified by the instances of arrested development occurring as the result of the toxic action of syphilis, tuberculosis, malaria, pellagra, etc. Correlative infantilism is seen when the growth and development of the body as a whole are arrested to accommodate the body to the retardation that occurs in any particular organ or groups of organs. Correlative infantilism is again subdivided into the endocrinous and the simple correlative. Endocrinous infantilism is illustrated by the cases of arrested development resulting from thyroid deficiency; and possibly by the cases associated with hypopituitarism, as in Fröhlich's syndrome; and also possibly by the cases of so-called suprarenal and pancreatic infantilism.

The type characterized as simple correlative infantilism is one in which the action of toxins or of hormones may be excluded, and includes cases such as those associated with achondroplasia, scleroderma, muscular dystrophy, congenital cardiac defects, hypoplasia of the arterial system, microcephalus, and hydrocephalus. Deprivational infantilism occurs when an essential constituent is lacking from the food, as in the cases of arrested growth resulting from the absence of the vitamines from the diet. There are mixed types of infantilism which include characteristics belonging to several groups.

Symptomatic infantilism may be of the Lorain type in which the arrest of growth is more obvious than the arrest of development, a type which was originally regarded as the result of an underdevelopment of the arterial system. In the Lorain type the individual is thin and angular with a tendency to debility. Symptomatic infantilism may, on the other hand, be of the Brissaud type which was formerly regarded as the result of thyroid deficiency and in which there is a tendency to obesity. Most of the cases of this type are now regarded as instances of pituitary disease or examples of idiopathic infantilism.

Idiopathic or essential infantilism or that form in which there is no apparent cause, is subdivided into ateleiosis, an unmixed infantilism (see *Ateleiosis*) and progeria in which infantilism and senilism are both manifest in the same patient. (See *Progeria*.)

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Infarction.—(*Infarcire*, to fill in, to stuff into.) The act of plugging up or filling up; also the organ or tissue which is filled with blood, fluid, or other substances. The development of the various meanings of infarction forms a very interesting chapter in the history of medical terminology. Originally used as a designation for the Galenic teaching of the black bile as the cause of melancholia and hypochondria, *infarctus* gradually came to mean a stoppage of the intestinal canal either through hardened fecal matter or through precipitations from the blood into the intestinal canal. Later, the idea included also obstruction in the blood and lymph vessels and the ducts of glands. The theory of intestinal infarctus as the cause of hypochondria, melancholia, hemorrhoids, and other conditions reached the height of its development in the latter half of the eighteenth century under the influence of the two Kämpfs, father and son. By them the doctrine was reduced to what was considered to be a scientific basis, the infarcts were obtained for examination by means of injections, and were classified according to symptoms, location, and composition. Their treatment by clysters attained an extraordinary degree of popularity. The abuse of this treatment and the advancement of knowledge of the anatomy and physiology of the gastrointestinal tract brought about the natural death of the doctrine during the early part of the last century. As outgrowths from the early idea of infarctus were such usages as the following: *infarction of humors*, a term formerly applied to ulcers whose base and borders were infiltrated; *infarctus mammæ lacteus*, the collection of coagulated milk in the ducts of the mammary gland; *infarctus lactei extremitatum*, applied to phlegmasia dolens because it was supposed to be caused by metastasis of the milk to the legs; *infarctus uteri*, applied to a variety of diseased conditions of this organ, etc. The term infarction was also formerly used clinically to indicate a sense of fulness or oppression in the chest. The enlarged spleen in chronic malaria was called *infarctus lienis*. The old meaning of intestinal obstruction still survives in the expression *infarcted hernia*.

At present infarction is unfortunately used as a designation for two classes of pathological conditions essentially different in kind: (1) The infiltration of the tubules or tissue spaces of an organ with blood, blood pigment, uric acid or urates, calcium salts, etc. (2) The anemic necrosis of an organ or tissue due to an obstruction of its nutrient artery by embolism or thrombosis. The different processes are usually distinguished by some modifying term, as uric-acid infarction, anemic or hemorrhagic infarction, etc.; but when used without such the term is usually narrowed to the second meaning.

1. URIC-ACID INFARCTION.—In the kidneys of the new-born there is almost always present in the medullary pyramids a number of glistening, golden, or orange-red lines converging to the papillæ. These lines are easily scraped away with the knife and form a glistening orange powder on the moist surface of the organ. On microscopical examination the straight tubules are found to be filled with dark semitranslucent masses which dissolve on treatment with acetic acid, leaving behind an albuminous stroma. From the solution uric-acid crystals are formed. The epithelium of the tubules shows little or no change. The granules consist of crystalline spheroliths of ammonia urates. The condition is known as the uric acid infarct of the new-born, and was at one time supposed to be of medicolegal value as occurring only in infants who have breathed; but similar infarcts have been found in the kidneys of still-born children and in the fetus. In one case of ectopic gestation seen by the writer the kidneys presented an extensive degree of this condition. According to Spiegelberg, uric-acid infarct is present in only one-half of the children examined, being most marked after the second or third day

after birth. The condition may persist until the seventy-sixth day, but usually disappears early. When persistent, it may give rise to nephritis or cause uremia by the simple obstruction of the tubules. Neither the origin nor the significance of the condition is known. The change of metabolism following the establishment of pulmonary oxygenation, the slight degree of oxidation processes in the new-born, lack of ability on the part of the urine to dissolve the uric acid, are among the causes adduced in explanation, but no one of these is adequately supported. Uric-acid and sodium-urate infarcts occur also in the adult kidney in cases of gout or the so-called uric-acid diathesis. The appearances are similar to those in the new-born, but the condition is rarely so extensive. More frequently, scattered concretions are formed in dilated tubules.

Calcium Infarcts, Chalk Infarcts.—In senile kidneys, in osteomalacia and other destructive diseases of bone, in gout, in cases of poisoning with mercuric chloride, phosphorus, aloin, bismuth, etc., extensive deposits of lime salts, phosphates or carbonates, may occur in the tubules, the deposit taking place either in or upon the necrotic epithelium of the tubules. When visible to the naked eye, such deposits appear as opaque whitish or yellow streaks corresponding to the tubules, or as minute dots representing the glomeruli. Microscopically the deposits give the specific staining reaction with hematoxylin. Calcium-oxalate infarction occurs rarely as the result of ingestion of food containing large amounts of oxalic acid or in cases of disturbed metabolism. White streaks occur in the pyramids similar to those of phosphate infarction, but are distinguished from the latter by their insolubility in dilute acids.

Bilirubin Infarct.—In cases of chronic obstructive jaundice the collecting tubules of the kidney usually contain large numbers of bile-pigment casts. In tissue fixed with alcohol these appear as yellow or brown streaks in the cut surface of the medullary pyramids; in mercuric chloride fixation they have a bright green color. Uric-acid infarction is not infrequently combined with this condition, particularly in cases of icterus neonatorum.

Hematoidin Infarct.—In cases of hemoglobinuria, hemoglobinemia, and methemoglobinemia, due to poisoning, infections, extensive burns, etc., large quantities of blood pigment may be found in the kidney tubules in the form of brownish casts or irregular masses. The pyramids show radiating yellow or reddish-brown striæ. Usually the pigment does not give the iron reaction, and is therefore to be classed with the hematoidin group. Very rarely hemosiderin infarction occurs.

Melanin Infarct.—Very rarely in cases of extensive metastasis of melanotic sarcomata large quantities of melanin are said to be excreted through the kidneys. In such cases melanin casts are found in the tubules. It is doubtful, however, if the brownish casts described as occurring in these cases were composed of melanin; it is more likely that they were formed of blood pigment.

2. Anemic and Hemorrhagic Infarction.—The occlusion of a terminal artery by embolism or thrombosis leads to an anemic necrosis (anemic sequestrum) of the part supplied by the obstructed vessel. In the case of end-arteries having very slight collateral anastomosis the dead area remains anemic (anemic or white infarct); in situations where the end-arteries possess sufficient anastomosis to admit of the flow of blood into the affected area from the neighboring terminals the dead area becomes hemorrhagic (hemorrhagic or red infarct). The anemic variety is found in the spleen, kidneys, heart, brain, retina, and rarely in the liver; the red or hemorrhagic infarct occurs chiefly in the lungs and the area supplied by the superior mesenteric artery, very rarely in the uterus, adrenals, testes and kidneys. Under especial conditions of intense congestion and when the area of anemic necrosis is small, red or hemorrhagic infarcts may occur also in brain, spleen, retina, and kidneys. Many of such red infarcts are not true anemic infarcts; they represent local hemorrhages due to obstruction to the venous outflow (venous thrombosis). This is particularly true of the so-called hemorrhagic infarcts of kidneys, spleen, adrenals, and testes. Thrombosis of one of the great sinuses or of a jugular vein, or ligation of the latter produces similar pictures in the brain. The term *stasis-infarct* ("*stauungs-infarction*") has been proposed for these conditions.

Infarcts are usually found at the periphery of organs where they form cone- or wedge-shaped areas, the base toward the surface of the organ, the apex pointing inward. They may be single or multiple. They vary greatly in size, from pinhead areas up to that of the entire organ in the case of the kidneys, lung, spleen, adrenal, and testes, when the main artery is closed. The size is usually somewhat less than that of the area supplied by the obstructed artery, but this will vary according to the collateral circulation. As the result of the occlusion of a number of neighboring arterioles they are occasionally very irregular in outline. When recent, the anemic infarct is opaque, yellowish-white, slightly elevated, and somewhat firmer than normal tissue. A peripheral red zone is almost always present. Older infarcts are usually depressed and softer; in the case of those of large size there is usually a central softening. If organization of the dead area has begun the consistence may be firm. On microscopical examination the cells of the infarcted area show a simple or coagulation necrosis. In older infarcts liquefaction necrosis may be present. The red peripheral zone is found to be due to a narrow line of hemorrhage and congestion surrounding the dead area and may be explained as being of the nature of a hemorrhagic infarct in the zone of collateral anastomosis with the neighboring end-arteries. In later stages this zone usually becomes the seat of a leucocyte infiltration and fibroblastic proliferation. The leucocytes of the peripheral zone contain numerous fat and glycogen droplets. Fat is also found in large amount in the cells of the peripheral zone, the result either of resorption or of a degenerative fatty infiltration. Later numerous pigmented (hemosiderin) phagocytes are found about the edge of the infarct. The hemorrhagic infarcts are deep red to black in color, occasionally pale in very anemic individuals. They are usually much firmer than the anemic variety. As they become older they grow lighter in color, and softer if liquefaction necrosis occurs. If organization takes place without softening the infarcted area becomes lighter and firmer. The contraction of the newly formed connective tissue leads to depressions on the surface of organs in the case of both anemic and hemorrhagic infarcts. On microscopical examination the hemorrhagic infarct is found to consist of an area of necrotic tissue, the spaces of which are filled with extravasated blood. It is in fact only an anemic infarct which has become hemorrhagic. The term hemorrhagic infarction is applied also to the occurrence of simple hemorrhage in tissues; in the case of the kidney to the hemorrhage produced by obstruction of the renal veins. It would be better to drop entirely this confusing use of the term and restrict its application to the true anemic and hemorrhagic-anemic necroses produced by arterial obstruction.

Various theories have been offered in explanation of the fact that infarcts in one case are anemic and in another hemorrhagic. It is held by some that the anemic infarct is but a later stage of the hemorrhagic, produced by the removal of the blood pigment from the latter. Old hemorrhagic infarcts are not infrequently lighter in color for this reason, but the fact remains that anemic infarcts are non-hemorrhagic from the

beginning except for the small peripheral zone of hemorrhagic infarction surrounding them. The true explanation is probably to be found in the character of the collateral anastomosis of the affected vessels, as well as in local and general conditions of the circulation. Where there is rich anastomosis, as in the lung and mesentery, the obstruction of an end-artery leads to a temporary anemia which lowers the vitality of the tissue supplied by the obstructed vessel; later, an inflow from the collaterals (chiefly venous, but also to some extent arterial) takes place, but the damaged condition of the vessel walls in the anemic area leads to extravasation, chiefly by diapedesis, but also by rhexis. The increased permeability of the vessel wall may be due to lessened nutrition as the result of the stasis, or to infective or toxic injury. The infiltration of the tissue spaces thus produced leads to further damage of the part. Very rarely the local or general conditions of blood pressure may be such in organs in which hemorrhagic infarcts are usually produced that but little blood flows into the anemic area and the resulting infarct is pale in color. The anemic infarct occurs in organs whose end-arteries have but little anastomosis, so that no inflow takes place into the anemic area except just at the periphery, where a narrow zone of hemorrhagic infarct is formed. In cases of extreme local or general congestion this peripheral zone of hemorrhage may be greatly broadened, or in the case of small infarcts the entire area may become hemorrhagic. The inflow of blood is usually under such slight pressure that the integrity of the part cannot be maintained.

Under ordinary conditions the infarcts of the brain are always of the anemic variety, with more or less peripheral hemorrhage. Liquefaction of the affected area takes place, and if death does not result brain cysts may be formed. Occlusion of the coronary arteries by thrombosis, embolism, or sclerotic changes in the vessel walls produces anemic infarction of the myocardium, attended by more or less hemorrhage. The infarcts of the kidney and spleen are almost always of the anemic variety with a narrow zone of hemorrhage. True anemic infarcts of the liver are very rare. Embolism of the hepatic artery is said not to produce anemic infarction of the liver, but the writer has seen such a case. Thrombosis or embolism of small branches of the portal that do not anastomose with branches of the hepatic artery will produce small anemic necroses. Traumatic interruption of the hepatic circulation is said to produce large anemic infarcts. Obstruction of large branches of the portal vein may produce no infarct, or if one is produced it is red. In the normal lung the obstruction of a terminal artery will not produce infarction owing to the rich anastomosis. In conditions in which the pulmonary circulation is already embarrassed, as in the passive congestion of mitral disease, embolism or thrombosis of the pulmonary arteries is quickly followed by infarction. This is practically always of the hemorrhagic variety except in very rare cases, due to extreme weakness of the circulation. The conditions in the superior mesenteric artery are similar to those in the lungs, but inasmuch as the anastomosis is not sufficient to reestablish the circulation after occlusion, obstruction of the terminals of this artery leads more quickly to infarction than in the case of the pulmonary arteries. According to Chiari, bilateral embolism of the hypogastric arteries or bilateral thrombosis of the uterine veins is followed by hemorrhagic infarction of the uterus.

The sequelæ of infarction are absorption of the necrotic tissues, organization, scar formation, calcification, cyst formation, encapsulation, abscess, or gangrene. In cases of infective embolism suppuration of the infarcted area usually occurs (septic infarct), or the infarct may be secondarily infected by pyogenetic organisms. Infarction of the lungs is frequently followed by moist gangrene, infarction of the intestine almost always. Infarcts of the heart cause fibroid heart, cardiac aneurysm, and heart rupture.

ALDRED SCOTT WARTHIN.

Infection. When microorganisms, either bacteria or protozoa, gain entrance to the tissues of the living animal body, and are there capable of maintaining themselves and multiplying, we speak of the process as "Infection."

The living nature of infectious agents was not clearly established until the similar causation of fermentation and putrefaction had been gradually elucidated by the work of Cagniard-Latour, Schwann, and others—and finally by that of Pasteur. And it seemed entirely reasonable to suppose, when the etiological similarity of these phenomena had been determined, that the simple introduction of bacteria into the animal body, should furnish all the necessary conditions for the accomplishment of infection. It was soon found, however, that the problem is one of far greater complexity.

In the case of the cleavage of dead organic matter, indeed, the mere lodgment of germs capable of producing ferments and proteolytic enzymes, upon a suitable pabulum, under condition of temperature and environment which favor the growth of the invader, will result in fermentation and putrefaction, as the case may be. For the material acted upon is passive here, is dead. In infection on the other hand the bringing together of the two reagents, invader and invaded, is not sufficient, since the material attacked by the germs, in this case, is not merely a passive medium, but is a living active animal tissue which can mobilize to its defense a powerful mechanism which opposes the biological activities of the infecting germ.

There is throughout nature on opposition to the colonization of one living being on or within the tissue substance of another. Bail has expressed the conditions most clearly and refers to this natural law as "das Gesetz der Lebensundurchdringlichkeit." It is this vital resistance which accounts for the fact that within a few hours after death microorganisms from the intestine, limited to this locality during life, will swarm through the circulation and enter the tissues. It is the same principle which will permit a mass of living frog's eggs to remain sterile in a pond swarming with microorganisms of all kinds, while the death of the eggs by frost or some other fortuitous injury will soon reduce their mass to a teeming culture of bacterial life.

The analysis of the mechanism of this vital resistance to infection is the science of immunity. The injury resulting to the animal body in the struggle between the invading forces and the defensive mechanism, is infectious disease. And the striking of a balance between invader and invaded, each bringing to the contest a number of offensive and defensive weapons determines the extent of the infection and the eventual outcome in recovery or death.

The living bodies of animals and man are in constant contact with innumerable microorganisms which abound in the air, in water, in foodstuffs and in nature generally, and some of these are normal and constant inhabitants of the body surface and of the various body cavities. Most of the organisms so found have not become biologically adapted to life upon the substance of the living cell. These are *saprophytic* in that they can develop and thrive only upon dead organic matter, and their biological attributes quite deprive them of the power to invade. It is plain therefore that a pure saprophyte cannot cause a true infection and that for the accomplishment of such a process it is necessary that the microorganism should be of a species which has developed *parasitic* characteristics, or in other words the ability to thrive upon the living tissues. It is probable that originally all

microorganisms were saprophytes, and that parasitic attributes were gradually developed in definite species which adapted themselves in temperature, in cultural requirements, and in special defenses and offenses, to the conditions found within the living animal. On this basis Bail has conveniently classified bacteria into:

1. Pure saprophytes, which are incapable, under any circumstances, of invading living tissues.

2. Half parasites, which though essentially saprophytic in nature may invade the living body if conditions are peculiarly favorable, and

3. Pure parasites, microorganisms which possess the power to infect when introduced in small numbers and by any number of different paths.

Although, therefore, to be truly invasive, bacteria must be to some extent, at least, parasitic, it must not be supposed from this that the term *saprophyte* is absolutely synonymous with the term *non-pathogenic* or that *parasitic* necessarily means *pathogenic*. For such microorganisms as the diphtheria bacillus may lodge upon the mucous membranes of the upper respiratory tract, without at any time possessing the power to penetrate the tissues, and may yet produce a severe disease by elaborating poisons which are absorbed to the detriment of the body. Essentially therefore these bacteria are saprophytic in their mode of growth, and yet they are powerfully pathogenic. The same thing, though less clearly, is true of tetanus, in which the bacilli do not, as a rule, invade beyond the original point of lodgment and are merely capable of holding their own at this point, the disease resulting not from further bacterial invasion but from the absorption of the elaborated poisons. On the other hand, such organisms as the trypanosomes common in wild rats or some of the gregarines which infest the sexual organs of earthworms may be in every respect true invaders without causing, at least extensively, any manifestations of injury to the host. The conditions in such cases are probably to be accounted for by a mutual adaptation so perfect that the presence of the invader no longer arouses a reaction in the host, a condition analogous to that which biologists designate as symbiosis. However, in the large majority of cases the power to produce disease depends primarily upon the ability of the germs to enter the living tissues and thrive there, an ability which of course presupposes adaptation to a parasitic mode of existence. In many cases, indeed, we must imitate such conditions by the use of animal protein and body temperature in order to succeed in the cultivation of these organisms in artificial laboratory media.

Since the conditions prevailing within the animal body in regard to the nature of tissue protein, body temperature, and other respects less easily definable, are not entirely alike in any two species of animal life, it is but natural that many bacteria have developed parasitic—and consequently infectious characteristics for definite groups of animals only. Thus it is almost a rule that organisms capable of invading warm-blooded animals rarely have infectiousness for the cold-blooded species, and *vice versa*. Tubercle bacilli of birds will rarely invade mammals since they do not thrive at the lower temperature found in the latter. And among the mammals themselves many infectious diseases are limited to an individual species. Many diseases of man are never spontaneously developed in animals. In cases like the gonococcus infections, our inability to cultivate these germs without the addition of human protein to the media, indicates a nutritional adaptation. In many cases, however, the adaptation is not so easily accounted for and cannot be defined in the simple terms of temperature and cultural conditions.

A further important factor upon which the ability to invade depends, even when the species is "pathogenic," is the *path* by which the microorganisms gain entrance into the animal body. There are bacteria like the anthrax bacillus which can cause infection when introduced by a variety of different paths. On the other hand microorganisms like the typhoid bacillus and the cholera spirillum can do injury only when introduced by way of the mouth, whereas lodged upon the broken skin they would be incapable of producing infection. Conversely streptococci and staphylococci and many other germs taken into the mouth and ingested would rarely lead to infection unless they encountered definite breaks in continuity of the mucosa, but these microorganisms and many others, rubbed into the skin would rapidly penetrate and cause disease. Such examples might be multiplied, but it is our purpose only to define general principles and it is plain, from the few examples given, that the path of introduction forms an important factor in determining whether or not an infection shall take place.

When the bacteria are brought into contact with the body by the path most suited for the development of their pathogenic properties, be this by mouth or by external contact, it is by no means necessary in all cases that they meet with an anatomical defect in the natural defensive coverings of skin and mucosa. Such a break in the antibacterial armor of the body will, of course, facilitate the penetration of the germs. But it seems quite certain that typhoid bacilli and cholera spirilla may penetrate into the mucosa and lymphatics without previous injury of the intestinal lining, and recent investigations have shown that tubercle bacilli may penetrate through the intestinal mucosa without visible lesion. Of rabic virus it has been claimed that it may enter through the unbroken conjunctiva and similar claims have been made in the case of glanders. The vigorous rubbing of plague bacilli into the shaven skin of susceptible animals regularly results in infection—the so-called Kolle "vaccination method" of inoculation. In all such cases, however, it would appear to us that while no anatomical break in skin or mucous membranes is present, there may nevertheless be for some reason a physiological defect, produced by slight inflammation, pressure, or trauma that would reduce the functional activity of the cells in question, and facilitate the penetration of the germs.

Even when a species is "pathogenic" and the path of introduction is suitably adapted to the requirements of the invading bacteria, it is still important that the bacteria shall be introduced in sufficient number or *dose*. A minute amount might rapidly succumb to the first attack of active serum and phagocytes, and the invaders be overcome before abnormal conditions had been sufficiently developed to be clinically appreciated as infection. It is, therefore, necessary that the invading bacteria shall be in sufficient number to withstand the rapidly mobilized defensive mechanism and gain a foothold for more extensive resistance.

When bacteria are capable of causing infection even though introduced in minute quantity, we speak of them as being highly "virulent." Virulence and dose are, therefore, in inverse proportion and we measure the virulence of a microorganism for any given species of animal by determining the minimal dose which will produce a fatal result, in an animal of standard weight. The bacteria are measured either by the standard loopful, in definite volumes of a young broth culture, by actual moist weight, or, most accurate of all, by Barber's method of picking up single threads or even individual bacteria in especially constructed capillary pipettes. Although all of these methods except the last, are subject to considerable experimental error, yet they are sufficiently accurate to show us that there is not only a great difference between various bacteria in their infectiousness for a given host, but that different strains of one and the same bacterial species may be entirely unlike each other in this respect.

If we should isolate a number of strains of pneumococci from different sources and test the virulence of

these organisms upon, let us say, white mice, we would find that no two of the bacterial cultures would have exactly similar degrees of invasive power. That to a certain extent these differences, too, depend upon delicate processes of adaptation, similar in principle to, but vastly more rapid in development than the original adaptation of the species to parasitic modes of life, is apparent from the methods by which fluctuations of virulence can be experimentally produced. For instance, a pneumococcus grown for many generations upon artificial media devoid of animal protein, will gradually lose much of its invasive power and larger quantities will be necessary to produce fatal infection. Also exposure to more than the optimum temperature, as in Pasteur's anthrax vaccine, or infrequent transplantation, or the addition of chemicals like carbolic acid to the culture medium will reduce the invasive power of the strain. There are many other methods long in use in bacteriological laboratories for accomplishing the same purpose, the enumeration of which, however, would not add materially to an exposition of the underlying principle. Conversely, if we wish to increase the invasive power of a microorganism for a given species this can often be accomplished by repeatedly passing the bacteria through the animal body, reinoculating each subsequent animal directly from the blood or exudate of the one which has succumbed. In this way, gradually, the dose necessary for a fatal issue can be reduced. It is reasonable to suppose that this is due to the fact that the bacteria in such cases, by adapting themselves to the conditions to which they are subjected in the animal body are increasing their specific ability to withstand the defensive mechanism brought to bear against them by this particular kind of animal. The delicacy of such adaptation is further evident from the fact that this process while increasing the virulence for the particular variety of animal through which the organism is being passed, may at the same time reduce the virulence for other species. Thus Pasteur showed that the passage of hydrophobia virus through monkeys reduced its virulence for rabbits, and in the case of swine plague he found that the bacilli passed through rabbits and pigeons gained enormously in virulence for these animals but lost in invasive power for hogs. To a certain extent the same principle can be illustrated by experiments outside the animal body, for if we wish to preserve the virulence of cultures under artificial conditions for any length of time, we may do this successfully by storing the bacteria in animal fluids or tissues. A simple example of this is the method devised by Neufeld in which the preservation of pneumococci within the spleen of animals dead of these bacteria, permits prolonged storage without appreciable loss of virulence.

While it is easy to describe the empirical facts regarding fluctuations of virulence it is not a simple matter to analyze the factors to which such gain or loss or virulence can be attributed. We may say in general that the virulence of a given microorganism may depend upon (1) the acquisition of higher resistance to destruction, a purely passive characteristic, and (2) the development of active aggressive properties on the part of the microorganisms.

The former property may be looked upon as a sort of immunization of the bacteria against the defensive powers of the subject. Experiments like those of Walker and others seem to indicate that bacteria habitually grown in the presence of immune sera lose much of their susceptibility to the action of the serum. Working with typhoid bacilli Walker found that, cultivated for a number of generations on typhoid immune serum, the microorganisms lost much of their susceptibility to agglutination by this serum and became at the same time considerably more virulent. A simpler example of such development of resistance on the part of bacteria is found in the experiments of Danysz who observed that the systematic cultivation of anthrax bacilli on media containing arsenic gradually induced a relative arsenic resistance. It is plain, therefore, that even as the animal body may be gradually immunized to the bacteria so the bacteria may be gradually immunized to the defenses of the animal body, a principle first emphasized by Welch.

The change in the resistance of the bacteria to the animal defenses may proceed entirely without visible morphological alteration. On the other hand, there is much evidence to indicate that the higher resistance of the microorganism is accompanied by definite structural change. In the experiments of Danysz, as the anthrax bacilli gained in resistance to arsenic they at the same time acquired a structure which is spoken of as the "bacterial capsule." It is well-known that microorganisms like the Friedlander bacillus, which are habitually and heavily capsulated, are possessed of a considerable degree of invasive power. Furthermore anthrax bacilli, plague bacilli, and other microorganisms which on artificial culture media rarely or never show capsules, may by suitable staining be shown to possess these envelopes when directly taken from the organs of animals dead of the infection. Pneumococci and streptococci which in the artificial culture, especially in media not containing animal protein, do not possess capsules will rapidly and characteristically develop them when passed through the susceptible animal body, and will often retain them on artificial culture for several generations if suitable protein is added. It is well-known from the experiments of Porges, furthermore, that capsulated bacteria, ordinarily inagglutinable in serum may become amenable to this serum activity if the capsule is first removed by heating in decinormal acid. Gruber and Futaki, also, have shown that capsulated bacteria will not be taken up by leucocytes even when, in the same preparation, uncapsulated organisms of the same species are readily ingested. It is, of course, well known that the phagocytosis of virulent pneumococci and streptococci takes place much less readily than does the similar phagocytosis of a virulent, uncapsulated strains. It seems, indeed, as though the virulence of bacteria can be enhanced at least to a certain extent, by the development of a sort of ectoplasmic insulation against destructive agencies of the animal body, a conception which becomes the more comprehensible if one considers that the quasi-chemical union between serum constituents and bacterial protein seems to be a necessary precursor of bacterial destruction by serum or phagocyte. It may be objected to this conception that many highly virulent microorganisms do not under any circumstances develop demonstrable capsules. This is quite true, yet Bail has claimed that the capsule is after all only a definite form of ectoplasmic change, which in many so-called uncapsulated bacteria may take another morphological form. Typhoid and other bacilli injected in large doses into the peritoneal cavities of susceptible animals, so that these animals are rapidly killed, will often appear much larger than they seem to be in preparations from the culture as originally injected. Bail speaks of these forms as "tierische Bazillen," claiming that the enlargement signifies ectoplasmic swelling, functionally analogous to capsule formation.

This, however, is in all probability one phase only in the development of increased invasive power. It is likely that in addition to this the bacteria have at their disposal an actively offensive mechanism by which they can hold at bay the destructive forces of the host. This idea was probably first broached by Salmon and Smith who, working with hog cholera, suggested that these microorganisms gained their initial foothold in the invaded body by reason of a "poisonous principle" produced during multiplication, which to some extent paralyzed the defenses. Similar ideas were introduced by Bouchard and by Kruse. The earlier work of Vaillard seemed to show

that, in the case of tetanus at least, it may be the formation of true toxins which prevents the removal of the bacteria by phagocytosis. The injection of tetanus bacilli or spores alone, without previous injury of the animal tissues, often failed to produce the disease. However, the addition of small amounts of tetanus toxin to such injections led to the rapid development of typical symptoms.

In the case of organisms by which no true toxins are formed other explanations must be sought. Bail has assumed that virulent bacteria may produce, within the animal body, substances not produced in the test-tube, by means of which the defenses are paralyzed and the bacteria enabled to develop. He has called these substances "aggressins" and has based his assumption on the following experiments. He has injected virulent bacteria intraperitoneally into susceptible animals and, immediately after death, removed the exudates formed. These exudates he found to possess the following properties: (1) Sublethal doses of bacteria were rendered fatal by the addition of small quantities of these exudates, (2) lethal quantities were induced to kill more rapidly, and (3) the injection of the exudates alone served to produce efficient immunity in the animals so treated.

The point of view of Bail has not been generally accepted. Wassermann and Citron have attributed the activities of Bail's aggressins to bacterial endotoxins necessarily found in these fluids. Our own conception based upon experimental study, is that the aggressive properties of Bail's exudates depends upon the presence of poisonous substances analogous to Friedberger's anaphylatoxic substances to which we apply the name "proteotoxin." We believe that the reaction between the animal serum and the bacterial protein gives rise to the formation of these proteotoxins and that the addition of such proteotoxins to sublethal amounts of bacteria will have the same effect as that ascribed by Bail to his aggressive exudates.

By the preliminary skirmish which takes place between the invading bacteria and the body defenses, it is determined whether or not a true infection can be established. The subsequent balance struck between these forces determines the severity and extent of the morbid process. The defenses may be so overwhelmingly superior to the bacterial attack that cure is accomplished before the symptoms of infection are clinically recognizable. On the other hand, the opposing forces may be so well balanced, that the struggle at the point of entrance remains long undecided and a so-called "localized infection" is the result. In such cases, in the acute infections, as in other forms of acute inflammation, the tissues about the area of bacterial lodgment undergo certain changes which, in the main, we now recognize as protective in purpose. The blood supply in this area is increased and the capillary vessels are distended; there is congestion—that is slowing of the blood current, and, with this, plasma exudes from the vessels. In consequence, there is swelling with redness of the affected part. Leucocytes now emigrate through the capillary walls into the tissue spaces. When the infection is very severe there may be diapedesis of the red blood cells. There is formed, then, a battle ground in which a complete disarrangement of normal conditions has occurred. Bacteria grow and invade the cellular structures; poisons are either produced by actual secretion or are liberated in the course of bacterial disintegration; tissues are destroyed and become necrotic; microorganisms are killed by the bactericidal properties of the exuded plasma, and phagocytes engulf large masses of the invaders.

If the tide of battle turns in favor of the infected host, the process is soon circumscribed and limited, the bacteria are all destroyed, and gradual repair of the injured area takes place. In the center of the lesion where dead tissues (partly liquefied by leucocytic enzymes) and dead and living leucocytes and bacteria form, with the blood plasma, a fluid mass, or pus, the lesion eventually breaks down and discharges.

If, on the other hand, the balance of power falls to the side of the bacteria, one of two things may occur. The localized process just described may extend, and, together with this, the bacteria enter the adjacent lymphatics or even the blood stream; or again, when the virulence of the bacteria is extremely high, such extension may take place without even a temporary localization of the invaders—a generalized infection taking place with almost negligible symptoms at the point of entry. Thus a relatively mild staphylococcus infection of the skin will result in a painful and formidable localized "boil"—while a similar infection with a very virulent streptococcus may kill with generalized streptococcus invasion, nothing more than a little redness and edema being apparent at the initial lesion. Localization of an infection, therefore, is a sign of relatively high resistance.

The conditions described above, are characteristic, in the main, of the acute infections. They do not hold true, however, in the case of the so-called chronic infections in which the nature of the microorganisms quite alters the manner in which the tissues react. As examples we may cite tuberculosis, leprosy, and syphilis. In these conditions the microorganisms may enter the body, maintaining themselves there, and may very gradually invade, without inducing severe symptoms until a very firm and evidently generalized foothold has been gained. In the case of the acid-fast bacilli mentioned above it may well be that this is due to the great insolubility of the microorganisms which therefore do not irritate the tissues into a reaction until they have accumulated in considerable numbers. In the case of the *Spirochæta pallida* it is not impossible, as Theobald Smith has pointed out, that the adaptation between invader and invaded is biologically so perfect that the body is riddled with the microorganisms before the disease is clinically recognizable.

When an infection spreads from the initial point of lodgment it may do so by a number of ways. It is likely that bacteria are almost immediately transported by the blood and lymph channels into the general circulation, but are rapidly destroyed unless the resistance of the body is unusually low. Extension of the original lesion may take place by direct continuity, the bacteria invading more and more of the surrounding tissues as resistance is locally overcome. This is the case in such lesions as those of the large furuncle, carbuncle, or erysipelas. Extension may also take the path of the lymph channels. It is, of course, a well-known occurrence that the lymph nodes draining the area in which an infection is taking place will become swollen and tender and that red lines along the skin indicate a change in the lymph vessels themselves. Dr. W. C. Clark finds that a ligature placed tightly about the limb will soon cause a disappearance of the red lines above the point of ligature. It is likely, therefore, that the inflammatory changes indicated by the redness along the course of the vessels are due to irritating poisonous substances, and not to actual bacterial growth along the channels; on the other hand, bacteria may on occasion find lodgment in the channels, and secondary suppurative foci then develop along their courses. In the lymph nodes themselves bacteria may be caught as in a filter and here bacterial destruction very probably takes place, preventing the further passage of the organisms into the general circulation, or else secondary suppurative foci may be formed in the nodes themselves.

Again the bacteria may enter the blood stream either through the lymphatic system or directly, and the result is a *bacteriæmia* or *septicæmia*. In the large majority of cases in which blood culture reveals the presence of microorganisms in the circulation, it is

probable that these are merely temporary inhabitants continually discharged into the blood from the focus of infection, and destroyed by phagocytosis almost as quickly as they enter. In many cases of so-called chronic endocarditis it is a simple matter to show that the opsonic properties of the patient's blood, when measured with his own phagocytes, is at least equal to and often higher than normal. Also many cases of septicemia in which the focus of infection is surgically accessible, such as the septicemia ensuing upon mastoid disease, thrombosis of the jugular vein, or suppurations of the teeth, will often rapidly subside upon surgical treatment of the initial lesion. When the bacteria gain a foothold and grow in the circulation, an evidence that the resisting powers of the individual have been overcome, a fatal prognosis is reasonably certain.

Extension may also take place metastatically in that the bacteria, carried from the original focus by the circulation, find lodgment in other parts of the body and there establish secondary foci similar to the one occurring at the point of entrance. This condition is spoken of as a *pyemia*.

It is a peculiar fact that many invading organisms show a definite predilection for certain tissues. Thus gonococci originally lodged upon the mucous membrane of the genitalia, when they become generalized usually attack the joints, the bursæ, or the heart valves; leprosy bacilli have a predilection for the nerve sheaths; the cholera spirilla grow by choice in the deeper layers of the intestinal mucous membrane, and the virus of rabies and that of poliomyelitis how preference for the nervous system. Such predilection is quite distinct from the similar selective action on the part of the bacterial poisons and is inexplicable by any facts at present at our disposal.

That the localization of an infection may often be influenced by trauma is less difficult to explain. For it is self-evident that any injury to tissues must to some extent interfere with the exercise of those functions which make for defense, and dead tissue either in the form of necrotic cells or hematomata may furnish an ideal pabulum for the growth of the germs. In some cases, for instance tetanus, it is often necessary that tissue injury take place before the bacteria can gain lodgment. For tetanus bacilli injected into healthy tissues, with a careful avoidance of trauma, will rarely cause the disease, whereas the simultaneous injection of mechanically injurious substances, like glass-dust or agar, or the previous crushing of the tissues, will establish the conditions necessary for the initial growth of the bacteria.

Between the time of inoculation of the animal body with any given germ and the first appearance of symptoms sufficiently severe to be clinically recognizable there is always a definite interval which is spoken of as the *incubation time*. In the case of many of the diseases spontaneously acquired by man there is much regularity in the duration of this period which, consequently, possesses some diagnostic importance. This is not a surprising fact since it is more likely that the dose and virulence of the microorganisms accidentally entering the body are more or less similar in different cases, and since the resistance of normal individuals to any given infection does not, as a rule, fluctuate very widely. For incubation time is to a large extent dependent upon the quantity of bacteria which gain entrance, their virulence, and the degree of resistance, offered to them by the infected body. The higher the virulence, the larger the dose, and the lower the resistance, the shorter is the incubation time, and *vice versa*. The greater part of this period probably represents the time necessary for an accumulation of the organisms sufficient to interfere with the normal functions of the subject, both locally and systemically. Yet this is not the whole story. A part of the incubation time is apparently determined by the peculiar fact that bacterial poisons, even though rapidly absorbed, do not immediately act upon the susceptible cells. Thus in the cases of bacteria which admittedly injure the body by the elaboration of powerful toxins, a definite and necessary period must always elapse between the introduction of the poisons into the system and the appearance of signs of their harmful action in the form of symptoms. Tetanus poison injected into horses may not cause disease for a number of days. If we increase the dose of the poison the incubation time may be considerably shortened but it can never be entirely eliminated. De Waele in experimenting upon mice has shown that the incubation time for tetanus poison may be shortened from thirty-six to twelve hours by the injection of 3,600 lethal doses. But whatever the dose, this period could never be shortened beyond eight hours. There is at present no adequate explanation for this. It is clear, however, that the incubation, so-called, is made up of these two distinct phases, one the time necessary for the accumulation of the bacteria, the other the interval required for the action of the poisons.

After the bacteria have gained entrance to the body and the infection is in progress the symptoms which ensue in the subject are almost invariably both local and general. It is only in the very mildest infections that systemic symptoms are entirely lacking. Local symptoms have been sufficiently elucidated in our description of the process going on at the site of infection. The clinical picture of redness, heat, pain, and diminished function are due to the pathological changes, the increased metabolism in the area, the stretching of the tissues by exudate and finally the destruction and death of tissue cells. Systemic symptoms, when the infection is localized, are due entirely to the poisons absorbed from the lesion. When the infection is a general one, there may be added to this the consequences incident upon the destruction of parenchyma cells of organs, interference with the blood flow in important areas by septic thrombosis or embolism, and even mechanical capillary destruction by masses of bacteria—such for instance as are found in fatal anthrax infections. Poison-absorption, however, is admittedly by far the most important factor in giving rise to the systemic manifestations.

These poisons may be in the nature of soluble secreted *exotoxins*, or they may be derived from the body cells of the bacteria themselves. The older view of Pfeiffer held that the cell proteins of most bacteria contained within themselves a preformed, specific poisonous substance, an *endotoxin* which was liberated when cell death occurred and the bacteria disintegrated. This is still maintained by some observers. On the other hand, a view first introduced by Vaughan, and further developed by Friedberger, suggests that there are no specific, preformed endotoxins but that the reaction between any bacterial protein and the active serum constituents of the host gives rise to toxic protein split-products which are responsible for the systemic symptoms. These poisons which we prefer to call "proteotoxins" are non-specific and are similar in their pharmacological products irrespective of the species of bacteria participating in their production.

In a number of cases in which the toxins have individual pharmacological properties the systemic symptoms which follow upon their absorption present specific and diagnostically valuable characteristics. This is true chiefly of conditions like diphtheria, tetanus and botulismus, diseases caused by exotoxin-producing microorganisms which, as we have stated above, are not truly invasive or infectious in their modes of attack. In other diseases, in which true invasion occurs, we are at present inclined to believe that characteristic difference in the clinical manifestations of the various infections are caused not so much by specific properties of the poisons, as by differences in the habitual paths of entry, modes of invasion, distribution, and degree of accumulation of the bacteria

responsible for the diseases. The purely toxic symptoms in these maladies, though showing minor variations, thus present certain constant features which may therefore be taken as characteristic of infections generally.

The most important of these is fever. The increase of temperature almost always accompanies all but the mildest infections, and is present even in the chronic infections, though in these it may be late in appearance. It is probable that fever is due to the action of the bacterial poisons upon the thermal centers and it has been frequently shown that the injection of bacterial products apart from the living organisms can cause an increase in body temperature. It is interesting to note also that Vaughan, in his study of the toxic split products to which he attributes most of the systemic symptoms of bacterial infection, has succeeded in producing fever curves, characteristic of many infectious diseases by the spaced injection of these substances. It is also true that, whereas the injection of small quantities of these proteotoxins will produce a rise of temperature, very large amounts will result in a rapid fall, a fact which is especially interesting in view of the drops of temperature frequently observed in patients of low resistance or in those overwhelmed by the severity of an infection.

Together with fever there is usually some alteration on the part of the leucocytes per cubic millimeter and in the relative number of polymorphonuclear leucocytes. It is a curious fact that in the case of most acute pyogenic infections an increase in the total number of leucocytes with a relative increase in the polymorphonuclears occurs. In some infections like typhoid, influenza, tuberculosis, and a few others the leucocytes may be temporarily diminished, and with this a relative lymphocytosis may occur.

These differences showing, as it were, a selective chemotactic influence are hard to explain. In the case of the leucopenia of typhoid fever and some other diseases, we are inclined to believe that the rapid production of proteotoxins in this infection is partly responsible for the diminution in leucocytes since it has been variously shown that these poisons, experimentally administered, may produce this effect. In tuberculosis and infections by the acid-fast bacteria generally, it seems that the polymorphonuclear leucocytes possess no ability to digest these microorganisms and this may account in a purely functional way for the selective accumulation of the lymphocytic cells about the tuberculous foci.

There is often, if the infection is severe enough, an enlargement of the spleen, there may be a destruction of red blood cells by bacterial hemotoxins, eventually leading to anemia, injury to white blood cells by bacterial leucocidins such as those produced by the staphylococci, and eventually the bacterial poisons may even produce actual degenerative lesions in various organs such as the liver, kidney, and heart muscle.

It is a question also whether fever is a process of conservation or must be looked upon simply as an evidence of injury. The experiments of some investigators seem to show that animals kept at high temperatures in the incubator, after experimental infection, may live longer than controls. The chilling of animals also has been shown to render them more highly susceptible to infection. However, neither of these lines of research can be regarded as conclusive and we are considerably in the dark concerning the true significance of temperature changes.

In infectious disease, then, we have a morbid condition which is directly due to the invasion of the body by parasitic microorganisms. Certain general symptoms are caused by the disturbances of function common to all cases in which a foreign living unit attempts to colonize in or upon the cell complexes of another. By these symptoms we may recognize when an "infection" has taken place. The path of entry, mode of invasion, specific accumulation differ somewhat among invasive bacteria and these characteristics call forth reactions in the infected body, sufficiently characteristic often to permit us to divine the nature of the infection by clinical data alone. However, in many cases when there is little or no difference between the above-named biological properties, the diseases produced by bacteria far removed from each other in botanical relationship may be closely similar. Thus the pneumonias caused by pneumococci may differ from those caused by Friedlander bacilli in severity only; acute meningeal infections caused by staphylococci, pneumococci, or meningococci may be closely alike in onset and early course; and the septicemias caused by a number of different microorganisms may be entirely indistinguishable. In all such cases the nature of the infection can be recognized only by actual isolation of the responsible germs.

The "specificity" of infectious diseases, thus, is not as strict as formerly assumed, and is not so exclusively dependent upon differences in the pharmacological action of the endocellular or other poisons emanating from the bacterial protoplasm. As far as it exists at all, it is due to the fact that species constancy in choice of a path of entrance, in mode of invasion and distribution, and often in chemical constitution on the part of the invaders, gives rise in each case to characteristic reactions in the infected animal body. In consequence the product of the two reagents often presents a uniform clinical picture which we recognize as definitely signifying infection with a special microorganism.

HANS ZINSSER.

Infiltrations.—The collection of fluid or cells in the tissue spaces, and the deposit in or between the cells of substances abnormal in kind or quantity, are included in the comprehensive class of *pathological infiltrations*. The processes involved are of widely differing nature; each variety of infiltration being usually indicated by some modifying designation, *hemorrhagic*, *inflammatory*, *tuberculous*, *leukemic*, *tissue infiltration*, etc. Without such specific designation infiltration is commonly taken to refer to the presence of some pathological substance in or about the cells, and is used as a synonym for pathological deposit. The infiltrated substance itself is also usually spoken of as an infiltration.

Fluid Infiltrations.—Edema, non-inflammatory in origin, is sometimes spoken of as an hydropic or dropsical infiltration. As a result of injury to the bladder or urethra extravasation of urine into the surrounding tissues, particularly into the perineum, may occur (urinary infiltration). Extravasations of blood, lymph, chyle, milk, fecal material, etc., are also styled infiltrations.

Inflammatory Infiltrations.—These may be hemorrhagic, serous, fibrinous, or cellular in character. The collection of serous exudates in tissue spaces is usually spoken of as inflammatory edema. Fibrinous infiltrations occur in diphtheritic inflammations and other forms of coagulation necrosis. The cellular infiltration of inflammation is for the chief part composed of leucocytes that have migrated from the blood-vessels. Wandering cells arising from proliferating tissue cells may also be found in it. Usually the leucocytes are of the polynuclear variety, but occasionally the infiltration is made up entirely of mononuclear forms. In some cases the cells of the infiltration are chiefly plasma cells; in other cases eosinophile or mast cells may be very numerous. The significance of these phenomena is as yet unknown. A leucocyte infiltration of moderate degree is usually spoken of as a small-celled infiltration; when the leucocytes are in large numbers as a purulent infiltration. (See *Inflammation* and *Exudations.*)

Leukemic Infiltration.—An increase in the number of the leucocytes in the blood is attended by an increase in the number of the wandering cells in the tissue

spaces. This increase is greatest in such organs as the liver and kidneys, and in the submucosa and mucosa of the gastrointestinal tract. In leukemia the accumulation of leucocytes in the interstitial tissue throughout the entire body may reach an enormous degree. They are more common in chronic lymphatic leukemia and in chloroma. The liver and kidneys become enlarged, firmer, and lighter in color as the result of such an infiltration. This may be diffuse, or circumscribed grayish-yellow areas of infiltration may occur throughout the organ (leukemic nodes, lymphoma). The mucosa of the larynx may be infiltrated to such an extent as to give rise to symptoms of edema of the glottis. In the intestine the swelling of the mucosa may be followed by ulceration. In chloroma green infiltrations of the periosteum and neighboring tissues form one of the most striking features of the disease. Such infiltrations are especially marked on the cranial bones, sternum, and vertebræ. The variety of leucocyte present in the infiltration depends upon the kind of leukemia, though in some cases of mononuclear leukemia the proportion of polynuclear forms in the tissues far exceeds that in the blood. Proliferation of the migrated cells occurs, as shown by the occurrence of cell-division figures.

Tumor Infiltration.—The malignant neoplasms, carcinoma and sarcoma, invade adjacent tissues by extension through the tissue spaces in the direction of least resistance, usually through the lymph spaces. This process is styled growth by infiltration. Extension in this manner is always more marked in the case of carcinoma than in that of sarcoma. The cells of the neoplasm push between the tissue cells and by their greater vitality cause pressure atrophy or necrosis of the latter. The neoplasm may grow in this way so gradually and uniformly that it seems to be sharply circumscribed as if growing by expansion. Around the infiltrating growth there is almost always present a zone of leucocyte infiltration as evidence of the inflammatory reaction produced by the development of the tumor. In many cases it is very difficult or impossible to distinguish between the leucocytes and the young tumor cells.

Tissue Infiltrations.—The term infiltration is very frequently used as a synonym for both pathological degenerations and deposits (albuminoid, hydropic, fatty, glycogenic, cholesterin, mucous, hyaline, amyloid, calcareous, uratic, and pigmentary infiltrations). Inasmuch as in the majority of these conditions the process is of the nature of a deposit in the affected tissue, the designation of pathological deposit seems preferable to that of infiltration. (See *Degeneration* and *Deposits.*)

Tuberculous Infiltration.—The confluence of small miliary tubercles may give rise to a diffuse tuberculous process, or the epithelioid tissue of tubercles may infiltrate into the neighboring tissues after the manner of a new growth. Both of these conditions are included under the head of tuberculous infiltration. The term gelatinous infiltration was used by Laënnec to designate the grayish-red fibrinous exudate filling up the lung alveoli in the neighborhood of tubercles.

Syphilitic Infiltration.—Circumscribed or diffuse gummatous processes affecting bone were formerly designated as gummatous infiltrations.

Granulomatous Infiltrations.—The other specific infective granulomas (leprosy, blastomycosis, actinomycosis, etc.) likewise cause tissue-infiltrations.

Parasitic Infiltration.—The presence of large numbers of bacteria in the tissue spaces, the occurrence of the filaria in the lymph spaces and vessels, the invasion of muscle by trichina, etc., are frequently designated as infiltrations. ALDRED SCOTT WARTHIN.

Inflammation.—*Definition.*—Inflammation has been defined as the response which the tissues make to injury. This definition has been modified by different pathologists so as to include or exclude some or other of the various phenomena which accompany inflammation, but in this simple form it is quite satisfactory as a general working definition.

CAUSES.—The inciting agents in inflammation are either living or non-living. In the first group, are included microorganisms of various types, such as bacteria, moulds, protoza, etc., and the more highly organized animal parasites; for example, the *Trichinella spiralis, Tænia echinococcus,* and other of the parasitic worms. The non-living agents include both physical and chemical forces and comprise pressure, friction, extremes of heat and cold, light, especially ultra-violet light, electricity, and Röntgen and radium rays. In this group are also solid or fluid substances, such as metals, acids, alkalis, or irritating liquids of an organic nature, like croton oil; organic particles such as cotton, linen, silk fibers, fragments of wood, and bone; and, finally, dead bacteria, some varieties of which may through their toxins set up an inflammatory reaction.

CLINICAL SIGNS OF INFLAMMATION.—Inflammation in the clinical sense is accompanied by a number of characteristic signs; heat, redness, swelling, pain, and impairment of function, the *calor, rubor, tumor, dolor,* and *functio læsa* of classical medicine. Some authorities, among them Ribbert, would include also fever, leucocytosis, and such systemic accompaniments of inflammation, while others prefer to exclude these from a strict consideration of inflammation as a whole. The five phenomena just mentioned are the evidences of inflammation generally recognized, even by the laity, but it must not be supposed that they are all necessarily or invariably present. It is self-evident that the existence of several phases such as heat and redness can be determined only in superficial inflammation; deep lesions may show only pain, swelling, or impaired function.

FORMS OF INFLAMMATION.—It is convenient to begin the study of the underlying phenomena of inflammation with a description of the changes found in the tissues in an acute inflammatory superficial lesion which exhibits all the cardinal signs. The details of the special forms of inflammation will be considered under separate heads. The redness and swelling, which are most evident in the early stages of acute inflammation, are due to vascular disturbance, and chiefly to a local increase in the blood and exudation from the blood-vessels. Increased local heat accompanies them, also due to the augmented flow of blood to the part and not to any local production of heat. Investigation with accurate instruments has shown that the temperature never rises above that of the blood itself, though it may be as much as three or four degrees higher than that of the surrounding normal skin. Microscopic study of the conditions which occur with this redness and swelling demonstrate that there occurs a constriction of the smaller vessels of the part which is rapidly succeeded by local dilatation, affecting first the arteries and later the veins and capillaries. At the outset the blood flow in the dilated vessels is accelerated, but after a short period, usually not more than one or two hours, it is retarded. This slowing of the current results in the widening out and ultimate disappearance of what is known as the axial stream, a current occupying the center of the vascular lumen and rendered visible under the microscope by the suspended corpuscles. (Fig. 3392.) Coincident with these vascular changes there is an exudation of fluid from the blood- and lymph vessels into the surrounding tissue spaces, and this is usually accompanied by an emigration of leucocytes from the capillaries and veins and the escape of red corpuscles from the capillaries. The leucocytes quickly move toward the site of irri-

tation. If the irritation is sufficiently intense, the slowing of the blood stream may result in complete stasis and finally thrombosis in the affected vessels. If the irritation persists, the progress of events above recorded will continue and involve wider and wider areas around the central site of injury. On the other hand, if the irritation is slight, the process of recovery or restoration sets in promptly, commencing from the periphery of the affected portion and associated with the phenomena spoken of as repair. The pain which accompanies inflammation is chiefly dependent on the exudation and vascular engorgement in the area involved and is due to the increased pressure which is thus exerted on the nerve endings in the inflamed region. Hence it is usually throbbing in character, the exacerbations being synchronous with the arterial pulsations, and is temporarily relieved by pressure over the afferent blood-vessels or by cold or hot applications to the inflamed regions. Pain may be caused also by the pressure of an exudate occurring within the sheath of a nerve trunk itself and in this case is apt to be more continuous. With the onset of fluctuation or the formation of a definite abscess, the pain is apt to diminish, either because of the relief of tissue tension or the actual destruction of terminal nerve filaments. This is the ordinary course of inflammation in vascular tissues.

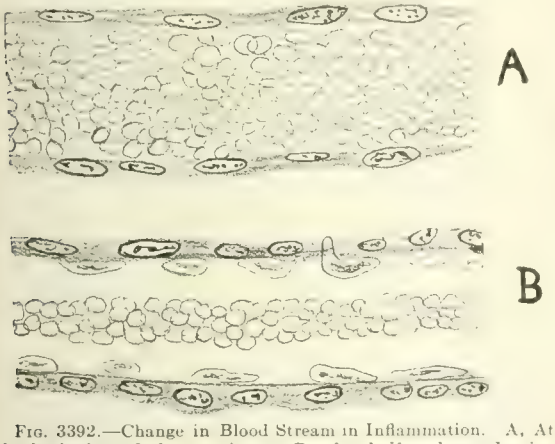

Fig. 3392.—Change in Blood Stream in Inflammation. A, At the beginning of the experiment; B, after half an hour, showing the axial stream.

In non-vascular areas the phenomena are somewhat different, but this difference is largely a qualitative one, owing to the absence of vascularity and the lateness or absence of corpuscular invasion of the tissues from the capillaries. The phenomena are best studied in the cornea. If this region is cauterized with a moderate irritant, or if a small amount of the superficial epithelium is removed by a sharp scalpel, the first thing to be noticed is that the exposed corneal corpuscles undergo necrosis and are absorbed. About this central ulceration is a zone in which the corneal cells are shrunken and become granular. Ultimately the degenerated epithelial cells break up and are dissolved, the products of their disintegration being carried off by the lymph channels. External to this area is found a region in which the corpuscles are swollen; their nuclei are more distinct and deeply staining than usual, and within a period of forty-eight hours may be seen to undergo mitotic division. These cells replace by their multiplication those corneal corpuscles which have been destroyed. If the cauterization has been sufficiently light, no change whatever is visible in the blood-vessels at the margin of the cornea and no emigration of leucocytes occurs into the affected parts. The reaction in such cases concerns only the tissue cells of the part affected. If the surface epithelium is removed, however, there is noticed within two hours of the injury a slight opacity in the corneal tissue just beneath the denuded area. Microscopic sections show that this opacity is due to the presence of leucocytes which have wandered into the wound and filled the tissue spaces in the neighborhood. These are cells derived from the conjunctival fluid, but no visible change occurs in the nearest blood-vessels, which are too distant to have supplied leucocytes for this infiltrating exudate. These leucocytes have been influenced by a force known as chemotaxis which, in some way not yet understood, induces them to move toward any area where tissue cells have been injured and are undergoing absorption. If, on the other hand, the cauterization has been severe, or if the operation has been done at a point near the margin of the cornea, there occurs, in addition to the changes previously described, a gradual invasion of the injured area by leucocytes emigrating from the nearest vascular loop. This invasion begins in about twelve hours and proceeds until the whole area is crowded with emigrated cells. Some, at any rate, of these invading cells are not absorbed but remain for a long time in the tissues, others are included and absorbed by the growing corneal corpuscles in the proliferating zone, while the great majority withdraw and within forty-eight hours have entirely escaped from the region, unless the process is a continuous one due to infection from the conjunctival sac. In the meantime, the course of regeneration proceeds as already described, the lost corneal corpuscles being replaced by the mitotic division of cells still uninjured, and the surface epithelium

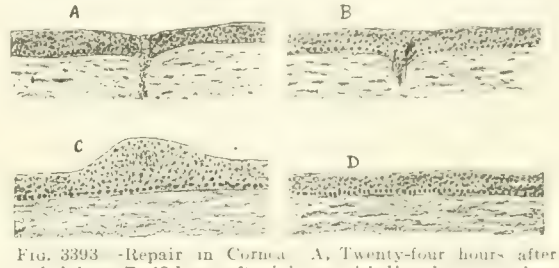

Fig. 3393.—Repair in Cornea. A, Twenty-four hours after aseptic injury; B, 48 hours after injury; epithelium has grown into the cut replacing the exudate; C, 72 hours after the injury; the lesion is replaced with overproduction of epithelium; D, one week after injury; complete return to normal.

by a similar multiplication of the corneal epithelium. The result usually exceeds somewhat the normal limits, so that a small mass of epithelial cells is produced, which, however, ordinarily disappears in the course of a few days. (Fig. 3393.) This is the phenomenon of overproduction, upon which Weigert has laid so much stress, and which has furnished Ehrlich with a means of explaining the production of antitoxin by the continuous overproduction of the protective substances which are used to combat bacterial or other poisons.

The fundamental processes which we observe in inflammation, therefore, are first, destruction of cells by the irritant or poison, and invasion of the tissues by leucocytes which are active in removing the products of injury to the cells. The next stage is the regeneration of these cells and the repair of the injury by mitotic division of the neighboring cells of both connective and epithelial type; but it is evident from the processes described in the cornea that the blood supply is only a secondary matter, and that perfect repair can be accomplished without vascular aid. The usual phenomena of inflammation, however, are accompanied by exudation from the blood-vessels and a resorption of the products of cell death through these channels. The repair may, therefore, be more active in vascular tissues, but blood-vessels are by no means essential for such repair. In addition to those processes which are purely local, inflammation may be accompanied by systemic disturbances, which may be very slight or may entirely dominate the field; for example, in the first stages of focal infection of the

skin the reaction may be purely local; but in a very short time before any of the microorganisms can be detected in the blood, there is a rise in temperature and other evidences of the absorption of toxic material from the local lesions. Later, the organisms may invade the blood current and incite active inflammation in other portions of the body. This does not, however, alter the fact that the inflammation, strictly speaking, is at first localized and that only as it extends does it give rise to general symptoms. Ribbert and others, as stated above, hold, however, that inflammation includes both the local and general processes. He cites the fact that even in small fairly well-localized infections there is a general leucocytosis and a development of bactericidal and antitoxic substances in regions distant from the area of primary injury, and also points out that there may be morphological evidences of general tissue alterations, such degenerative changes as cloudy swelling or fatty infiltration due to the diffusion of poisonous substances, either from the original inflamed area or from the local toxic action of organized bodies such as bacteria which have escaped from the region of active inflammation and have been deposited in distant tissues by way of the lymphatics or the blood stream. At the same time Ribbert admits that these general processes can be induced experimentally without necessarily giving any local disturbance. It is generally held, however, that inflammation is the local reaction to injury, and may or may not be accompanied or followed by systemic reaction, but that this systemic reaction must be excluded from a strict discussion of inflammation, as a pathological process. However willing we may be to admit that almost all the general processes begin as minute local infections, often giving no symptoms for a considerable period of time, still, in studying inflammation as a process, while we may refer to the systemic reaction, it is another thing to regard this reaction as an essential portion of the process.

Fig. 3394.—Exudative Inflammation in Granulation Tissue.

The forms of inflammation just described may be produced by irritating substances without the concurrence even of bacteria. If the organisms which ordinarily produce suppuration are present, the process, though it follows the stages described in the section on inflammation in vascular tissues, goes on to a further phase in which abscesses or diffuse purulent infiltration of the tissues occur. If, for example, small quantities of a pure culture of the *Staphylococcus pyogenes aureus* are introduced subcutaneously, the first alteration noticed is a proliferation of the organisms without marked tissue changes. This may last for only a few hours, then the vessels of the region are found to be densely filled with polymorphonuclear leucocytes which emigrate rapidly into the surrounding tissues. Within twelve hours the connective-tissue cells begin to swell, the exudation of leucocytes from the vessels is more extensive, and the organisms which have induced the infection may be found lying in the lymph spaces, in part free, in part contained in the phagocytic leucocytes. The exudation from the congested vessels leads to the production of edema, the plasma coagulating and forming a fibrinous network throughout the tissue spaces. Forty-eight hours are usually required for the development of a well-defined exudate. This exudate consists chiefly of densely packed polymorphonuclear leucocytes mingled with masses of staphylococcus organisms, tissue débris and fibrin. Some of the leucocytes are perfectly normal, others show fragmentation and degeneration of the nuclei. In the abscess area the peripheral capillaries are destroyed, and thrombi may be found in them. After a variable period, granulation tissue begins to be formed by the proliferation of the connective-tissue cells and the growth of fresh capillary loops into the abscess cavity. Gradually the leucocytes destroy the cocci, or at least remove them from the field, the exudation is discharged through the lymph channels and the capillaries of the granulation tissue; and ultimately the abscess is healed by a new growth of fibrous tissue which leaves a small subcutaneous scar or cicatrix. In the description just given, it is assumed that the abscess undergoes spontaneous absorption. Of course, it is true that in many cases such spontaneous absorption does not occur, and healing is not effected until the abscess is opened; but in experimental infections, when the dose of bacteria injected can be carefully estimated or when turpentine or other pyogenic substances are employed, such spontaneous healing is easily produced. These are the three forms of inflammation of the simpler type.

Cells of the Exudate.—A knowledge of the details of the inflammatory process implies a familiarity with the various elements taking place in inflammation and the process of repair; of these the leucocytes play an important if temporary part.

The Leucocytes.—Two forms of leucocytes appear constantly in inflammatory lesions. The one most frequently found in acute inflammation is the polymorphonuclear neutrophile leucocyte; that which is most abundant in chronic inflammation is the lymphocyte. In addition to these two types, which in adult life are produced in the bone marrow and the lymphoid tissue of the body, there appear many small cells which are probably derived from the tissues themselves, and are not directly connected with the blood-forming organs. It is possible, on the other hand, that some of the elements originally derived from the blood may undergo changes in the tissues which alter their morphology so as to make their histogenetic relationships difficult to determine. Maximow, for example, holds that the polyblasts, under which name he includes the hematogenous lymphocytes and the closely related adventitial cells and the endothelial leucocytes of Mallory, form mononuclear phagocytes, epithelioid cells, clasmatocytes, plasma cells, and even giant cells, but this somewhat radical view is not generally accepted.

It is convenient to divide the wandering cells found in inflammatory tissues into *hematogenous* or those derived from the blood stream itself, though primarily originating in the marrow or lymphoid tissues; this class includes the neutrophile, eosinophile, and basophile leucocytes, and the lymphocyte; *histo-*

hematogenous or such cells as are apparently derived from the lymphocytes of the blood, though they subsequently become so altered, either by proliferation in the tissues or by the action of fluids exuded in the course of the inflammation, that their morphology does not correspond with the standard lymphocytes of the blood; and *plasma*, which are generally considered to originate not only locally as the result of proliferation under the stimulus of the inflammatory agent, but also from altered hematogenous lymphocytes. Schridde calls this last group lymphoblastic plasma cells.

The microscopic details of the hematogenous leucocytes have already been presented in the article *Blood*, and need no detailed description here. Smears from the pus of an abscess or from a suppurative cellulitis show vast numbers of polymorphonuclear leucocytes, some of them with exactly the same morphology as that of the circulating cells, others showing pycnotic or other degenerative processes in the nuclei, or a necrosis of the cell body with a dis-

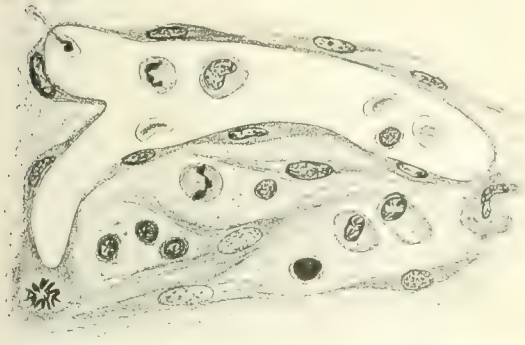

Fig. 3395. Capillary from Tissue undergoing Repair, showing emigration of leucocytes, newly formed fibroblasts, plasma cells, and lymphocytes.

appearance of the neutrophile granules, while still others are the familiar "basket-form" or degenerated cell seen occasionally in normal blood. In bacterial infection, the leucocytes are the chief phagocytic agents and are often filled with large numbers of phagocyted organisms. These are most frequently the staphylococcus, the pneumococcus, the meningococcus, and the gonococcus. The tubercle bacillus and some other organisms such as the typhoid bacillus are less frequently phagocyted under ordinary circumstances.

The eosinophile cells appear in inflammatory lesions only rarely when the process is of an acute nature and due to pyogenetic organisms. They are, however, very abundant about or in inflammatory areas when trichinæ or intestinal parasites are present. Blastomycotic infections also induce a local eosinophilia. The cells are found as well about certain types of gouty lesions, in the lymph nodes, in Hodgkin's disease, and in many inflammatory skin lesions, and not infrequently in large numbers in the regions of tumors, especially where the growth has ulcerated with the production of a large amount of granulation tissue.

As regards the basophile leucocyte, or mast-cell, it is rather improbable that any large proportion of the elements found in inflammatory exudates are the same as those seen in the circulating blood. It is much more likely that most of these cells containing irregular basophilic granules are tissue cells proper.

The remaining important type of cell is the lymphocyte. While it is generally assumed that this arises from bone marrow and lymphoid tissue, and, hence, is hematogenous in origin, there are many who consider that it is of mesoblastic origin and produced in the tissues, that is, by alteration of pre-existing connective tissue cells. Other writers hold firmly to the view that a double origin must be assumed, and that the lymphocytes are not only hematogenous but also histogenous in origin. The possibility cannot be excluded, finally, that though they are primarily derived by emigration from the capillaries, they may collect in the tissues and undergo mitotic division, producing areas of lymphoid tissue similar to that in which they were originally formed.

Method of Escape of Cells from Blood-vessels.—The method by which hematogenous cells escape from the blood current has been carefully studied, since the earliest days of experimental pathology, in the web of the frog's foot and the mesentery of the same animal. If the beginning inflammatory process in either of these situations is carefully watched under the microscope, it will be found that the primary dilatation of the capillaries is followed in an hour or two by a phase in which the current is slowed. The axial stream of blood corpuscles, originally well marked, becomes less evident, and, while the red cells pass along the center of the capillary lumen, an increasing number of leucocytes adhere closely to the walls of the vessel. As the current becomes slower, any distinction between the axial and peripheral streams is lost and the whole lumen of the vessel is filled with closely packed blood corpuscles. Finally, some of the leucocytes adhering to the walls of the smaller capillaries will be noticed each to put out a projection, which passes through the wall (Fig. 3395). Such leucocytes will be found gradually to follow their prolongation through the wall, and to escape into the tissues, and within five or six hours the region about the smaller capillaries may show a large number of emigrated leucocytes (Fig. 3394). At the same time a small number of red blood corpuscles make their escape through the walls of the damaged vessels, being probably extruded between the endothelial cells by a passive process known as diapedesis, and not through any activity on the part of the erythrocytes themselves.

The leucocytes do not remain very long in the immediate neighborhood of the vessels, but pass onward by active ameboid progression toward the area which has been injured. The process by which the eosinophile cells and the lymphocytes leave the capillaries is less open to experimental observation, because we cannot produce experimentally an inflammation in which these cells leave the circulation in large numbers. We have to judge, therefore, by analogy, and by the results of fixed and sectioned tissues, which often show lymphocytes in the process of passing through the wall. An exudation of eosinophile cells may be assumed because of the richness of cells of this type about the walls of the smaller capillaries and in the region of certain tissue invaded by such parasites as *Trichinella spiralis*. A local production is also probable.

The Histo-hematogenous Group of Cells.—In a discussion of these elements we enter immediately upon ground which is disputed, since practically no two pathologists agree in all the details of their relationship. The most important form is the plasma cell. This is a mononuclear cell which resembles to a certain extent the lymphocyte, except that its cell body is broader, its nucleus is apt to be eccentric, and the nuclear chromatin shows a spoke-like arrangement which is not ordinarily seen in the hematogenous lymphocyte. The body of the plasma cell is deeply tinged by basic dyes such as methylene blue except in a small area near the nucleus (Fig. 3395). By many they are assumed to arise in the tissues by the proliferation of pre-existing cells. On the other hand, perfectly competent observers point out that these cells are frequently found not only in the bone marrow

but in the spleen and lymph-nodes, and hence probably have a hematogenous origin. An additional fact pointing in this direction is that in certain leukemias and in connection with some tumors involving the blood-forming organs, plasma cells may appear in the circulating blood. This group of pathologists assumes that the lymphocytes pass through the capillaries and after reaching the tissues undergo certain changes which are correlated with the morphological structures known as plasma cells. While their origin is thus uncertain, their occurrence is recognized in a great many forms of subacute or chronic inflammation. They are regularly present in all sorts of granulation tissue, in chronic syphilitic inflammatory lesions, especially those of the mucous membranes, and in the inflammatory exudate which is found around carcinomata or wherever epithelial cells are undergoing absorption. As they may often be found twenty-four hours after the beginning of acute inflammation, the theory that they are derived from the perivascular lymphoid infiltration normally found in the tissues seems well founded. Councilman has pointed out their regular occurrence in certain types of acute interstitial nephritis in man.

Histogenous Cells.—Among the histogenous cells, one of the most important is the so-called "macrophage" which was first noted in experimental studies on inflammation of the endothelial (mesothelial) cells of the omentum. These cells, which are flat when seen under ordinary conditions, become greatly swollen in a few hours if the peritoneal cavity is irritated either by chemical agents or by bacteria. They

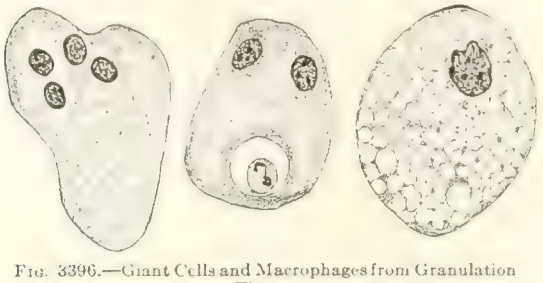

Fig. 3396.—Giant Cells and Macrophages from Granulation Tissue.

are actively phagocytic and take up bacteria, though they are not so active in this respect as the polymorphonuclear leucocyte. They are also apt to phagocyte other cells (Fig. 3396), such as partly degenerated polymorphonuclears, eosinophiles, or red blood corpuscles. This phenomenon of red blood corpuscle phagocytosis occurs when foreign corpuscles are injected into the peritoneal cavity, but it is also seen in man in cases of hemorrhage where blood has been set free in the tissues and carried by the lymph channels to the lymph-nodes. In the sinuses of the regional lymph-nodes large phagocytic cells may often be seen stuffed with phagocyted red blood corpuscles, and similar phagocytes of endothelial origin have been described by Mallory, who showed that they were frequently demonstrable in infections with the typhoid bacillus. With this same group belong the large phagocytic cells lining the sinusoids of the liver, the so-called Kupffer's cells, which frequently phagocyte particles of coal dust or malarial parasites. After transfusion, phagocytosis of the injected red cells has been seen in the blood stream, the active elements being apparently large bone-marrow cells with neutrophile granules or endothelial cells (Hopkins).

Similar large endothelial cells are frequently found acting as phagocytes in granulation tissue, here they are evidently derived from the endothelium of sprouting capillaries.

The ultimate fate of this type of cell is not known, though Metchnikoff has shown that when loaded with blood corpuscles of a species which is easily recognizable, they may be found in the mesenteric lymph-nodes and the vessels of the liver and the spleen. Similar elements, which are probably derived from the flattened epithelium lining the air vesicles of the lung, are regularly seen in pneumonia and in chronic heart disease, acting as phagocytes either of the bacteria or of blood pigment. It is not impossible, however, that even these cells are derived from the endothelium of the capillaries of the lung. The large mononuclear cells of the blood also belong to this group of phagocytic cells.

Another form quite distinct from the preceding are the clasmatocytes of Ranvier, which are long, branching cells with large oval nuclei, the bodies of which contain granules taking up basic dyes. (Fig. 3397.) These elements are found scattered throughout the tissues chiefly in low-grade chronic inflammation and are not present, as a rule, in acute suppurative processes. They are generally considered as histogenetic in origin.

In special types of inflammation, such as that due to the tubercle bacillus, large flattened tissue cells which are probably endothelial in origin, form the so-called "endothelioid cells" of the tubercle. When they fuse into large masses, or when the nuclei divide without corresponding division of the cell body, they give rise to the well-known giant cells which are so abundant in tuberculous and syphilitic inflammation, and which also occur about foreign bodies of all types. This fusion may even be observed in cultures of connective tissue *in vitro* (R. A. Lambert).

Fig. 3397.—Group of Fibroblasts in New Connective Tissue from Incised Wound. One clasmatocyte is seen to the right of the figure.

Functional Activities of the Exudate Cells.—The function of the exudate cells varies greatly. The polymorphonuclear leucocytes seem to be active in two ways; one, by furnishing digestive or protective ferments to the tissues, the other, by active ingestion of the infectious agents or bacteria which may be present in the localities inflamed. The digestive power is best seen in the destruction of tissue which occurs during the formation of an abscess resulting from the presence and activity of an organism such as the Staphylococcus aureus. This is the parasite which is most frequently found in the infection of the skin and subcutaneous tissue known as furunculosis, in which larger or smaller abscess cavities are regularly present. If the leucocytes or pus from such an abscess are removed and placed in a suitable medium containing proteid, this proteid substance will be digested, and, therefore, it may be assumed that a considerable portion of the tissue destruction depends upon the digestive action of the proteolytic ferments extracted from the leucocytes in the course of their degeneration in the tissues. In animals, whose leucocytes contain little or no proteolytic ferments and the plasma much antienzyme, abscesses, even when formed, are small and the pus is of pasty consistency, in contradistinction to the extensive abscess formation in man, whose neutrophile cells contain large amounts of protease.

The active immunizing power of leucocytes has been well demonstrated by Hiss who used an aqueous ex-

tract of an exudate produced by the injection of aleuronat into the pleural cavity of rabbits. This extract, produced by shaking up the resulting collection of polymorphonuclear leucocytes in distilled water, which dissolves the body of the cell, has been shown to possess a very considerable protective capacity when administered therapeutically especially in the diffuse streptococcus inflammation of the skin known clinically as erysipelas, and in some cases of acute pneumonia in human beings. The phagocytic activity of the polymorphonuclear leucocytes is also important, though whether they can ingest all types of live virulent bacteria is doubtful. They can certainly take up dead bacteria with ease, and the possibility that they can also include in their bodies bacteria which are alive and virulent has been proved for certain organisms. It is important to note, however, that the more virulent the organism, the less is it apt to be engulfed, while Wright has also demonstrated that phagocytosis does not take place extensively unless there is present in the serum a considerable quantity of an immune body which he terms an opsonin. Another factor also plays an important part in the process of phagocytosis, for the organisms cannot be ingested unless the leucocytes are attracted to the place where the organisms are abundant. This property of attracting leucocytes, which is apparently due to the toxic products of the bacteria, is known as positive chemotaxis, and probably accounts in large part for the presence of the enormous number of leucocytes which collect in and about an area invaded by bacterial organisms of particular species. Some bacteria possess the power of interfering with the approach of the leucocytes to the inflamed area and they or their products are, therefore, considered to have a negative chemotaxic power. In this instance, the bacteria are phagocyted very slightly or not at all by the polymorphonuclear leucocytes. Among these organisms is the typhoid bacillus, and here another factor enters the field, for such bacteria are apparently easily taken up by other cells, the macrophages or endothelial leucocytes of Mallory.

The functional activities of the eosinophile and the lymphocyte leucocytes are less well known. Those of the eosinophile cells, in man at least, have not been studied. It has been shown that the lymphocytes contain a lipase and a protease, the former capable of digesting fats, the latter, proteins in a faintly acid medium. But it is probable that they do not contain as active a ferment, or at least no such quantity of ferment, as the polymorphonuclear cells, and as the reaction of the tissues is faintly alkaline their ferments are presumably of secondary importance. Bashford and Da Fano have shown that the resistance to the transplantation of tumor tissue is not humoral but is apparently a factor of tissue activity and correlated with a lymphocytic and plasma cell reaction in the neighborhood of the cells of the beginning neoplasm. It is certain that in the chronic inflammation which occurs in the neighborhood of tumor cells undergoing resorption, these elements can be demonstrated in large numbers. Murphy has found that damaging the bone marrow and thus checking the production of the white cells by means of Röntgen rays permits the graft of a sarcoma of the mouse to grow in a rat for thirty-two days, thus showing that the lymphocytes and plasma cells do in some way carry or are concerned with tissue immunity.

The Exudate.—In addition to the cells which appear in the tissues in inflammation there is a great outpouring of fluid. The chemical studies which have been made on this fluid show that it resembles the blood serum in many respects, though it is usually a little lower in its protein contents. Analyses have been made chiefly on the fluids from non-infected wounds or on the exudates collecting in the thoracic or abdominal cavities of the body in consequence of chronic inflammation. The fluid portion of pus has also been studied after the removal of the leucocytes which it contained. The composition of these fluids varies a good deal. The amount of protein which comprises both serum globulin and serum albumin may be as high as five per cent. or fall as low as one per cent. The proportions of serum globulin and serum albumin vary a good deal in different exudates, a condition which is not yet understood. Nucleoproteids are found, derived chiefly from the leucocytes, and fibrinogen is present except in suppurative lesions. There is more or less non-protein nitrogen, which is probably due to proteoses and amino acids formed by autolytic processes taking place in suppuration from ferments derived from the leucocytes, fixed tissue cells, and bacteria. Glucose is present, as in the blood. Purins, alantoin, urea, lecithin, cholesterol, and fat are also regularly found in small quantities. All the enzymes of the blood plasma may appear in inflammatory exudates or individual ones may be absent. Lipase and oxidase and various proteolytic and glycolytic ferments have been found; and immune bodies such as cytotoxins, hemolysins, bacteriolysins, and agglutinins are present in exudates, if they are in the blood. Purulent fluid contains but little opsonin, whereas in serous exudates the opsonin content varies directly with the amount of the proteins in the fluid.

An important constituent of the exudate is fibrin, of which the amount varies greatly; it is usually inversely proportionate to the proteoses present. In simple inflammatory exudates such as occur in the pleural cavity the amount of fibrin formed may be relatively small. In certain types of inflammation, on the other hand, notably in those known as diphtheritic, though they are not necessarily due to the presence of the diphtheria bacillus, it may entirely dominate the picture. The fibrin is formed by the action of the tissue juices upon the fibrinogen of the exudate, which is, of course, derived from that of the blood. The fibrin may ultimately be dissolved by the action of the bacterial proteases or similar ferments set free by the destruction of the leucocytes or the tissue cells, or it may form a framework upon which new tissue growth occurs. This is often noticed in the peritoneal cavity where fibrinous adhesions are promptly covered by the endothelium lining that cavity. Such fibrin is soon penetrated by fibroblasts and is ultimately entirely replaced by these cells. A similar process is seen in vascular thromboses, where the endothelium of the vessel coats the mass of fibrin present and fibroblasts afterward grow in from the intimal layers and organize the thrombus. The functions of fibrin are the formation of adhesions for the prevention of leakage about injuries in the peritoneal cavity, and the stoppage of blood-vessels so that hemorrhage is not too long continued in case the vessel wall is eroded by the digestive ferment set free during the inflammatory process.

Repair.—With the cessation of the acute stage of an inflammatory process, regenerative activity in the tissue cells surrounding the affected area begins to dominate the picture. The multiplication of these elements is presumably due to some stimulus either from the bacterial products or the substances produced by autolysis of the tissue cells, and also to freedom from the normal tissue restraint which controls the morphology and growth of cells of the adult body. The action of stimuli on cells has in recent times been investigated in the effect of certain physical agents such as *x*-rays, radium, and ultraviolet light. It has been shown that moderate exposure of the ova of various lower forms of life, such as, for example, those of the frog or *Ascaris megalocephala*, induces segmentation and continued proliferation if the nutritional conditions are satisfactory.

If an excess of any one of these agents act upon the cells it causes either a perverted growth or a complete inhibition and ultimate death. The work of the experimental biologists has also shown that chemical substances may incite rapid cell division, even though these substances do not directly act as food, but merely stimulate the metabolic processes of the cells under experiment. The feeding of thymus tissue to tadpoles induces an increased rate of growth but checks developmental changes while the opposite is true of thyroid (Gudernatsch).

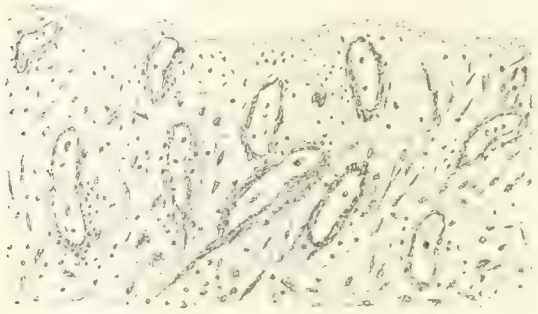

Fig. 3398.—Exuberant Granulation Tissue with Large Vessels and Edematous Stroma, and Layer of Fibrin, Bacteria, and Debris on the Surface.

The tissue formed in regeneration after inflammation, generally called granulation tissue (Fig. 3398), is composed of cells of various types, including fibroblasts, endothelial cells, leucocytes, and a number of forms as yet but little understood, such as the polyblasts of Maximow, plasma cells, and clasmatocytes (Fig. 3397.) The ultimate fate of the leucocytes and plasma cells is to disappear as the tissue becomes more mature; the fibroblast, on the contrary, organizes into adult connective tissue and ultimately forms a firm scar permeated by blood-vessels. These gradually diminish in number; hence a recent scar is red, while one of longer duration is pale in color. The pigment of the extravasated red blood cells, which are gradually

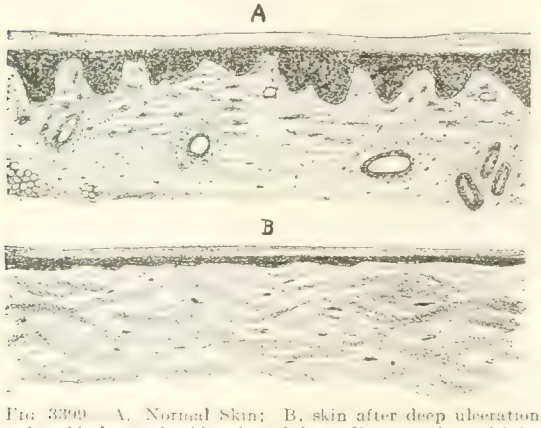

Fig. 3399.—A, Normal Skin; B, skin after deep ulceration, showing thin layer of epidermis and dense fibrous corium with few vessels and no glands.

phagocyted, often remains in the tissues for a long time.

The process of repair, however, is often complicated, for the newly formed connective-tissue cells frequently undergo various types of degeneration, such as fatty, mucoid, or hyaline, being then replaced by normal fibroblasts, which ultimately form fibrillar connective tissue, showing the fibroglia and collagen fibers characteristic of that type of tissue. The hematogenous leucocytes certainly are not transformed into fibroblasts, nor do the plasma cells undergo this change.

If the inflammation has involved epidermal or entodermal surfaces, epithelium from the neighborhood grows over the granulating area and ultimately forms a layer of covering cells, imitating the normal to a certain extent except that it is usually thinner and lacks some of the topographic characteristics of the adult normal tissues. Elastic tissue is also formed in a scar from cells which cannot be distinguished from those producing ordinary fibrous tissue, but such fibers are usually less abundant than in the corresponding normal tissues and their development takes place at a late stage of the process of repair.

While the tissue involved has so far usually been assumed to be subcutaneous tissue, a somewhat similar process occurs in organs and more complex tissues, modified only by the special circumstances under which the inflammation occurs.

If the inflammation is caused by certain organisms, it assumes a special type, as in lesions due to the tubercle bacillus, the Spirochæte pallida, the actinomycosis fungus, the blastomycetes, and certain rare yeasts and moulds. These special types of reaction are described under the headings of *Tuberculosis*, *Syphilis*, *Blastomycosis*, as well as in the article on *Granuloma*, where details are given more fully than is necessary here. FRANCIS CARTER WOOD.

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Influenza.—Influenza is an acute, self-limited, infectious fever, occurring in widely distributed epidemics, and characterized by catarrhal inflammation of the respiratory and gastrointestinal mucosa, by profound nervous disturbances, and by extreme debility.

Syonyms: Febris catarrhalis; Epidemic catarrhal Fever; La Grippe; Grip; Tac; Horion; *La Dando; Ziep; Epidemischer Husten; Epidemischer Schnupfen; Schafhusten; Blitz-catarrh; Modefieber; Mal Russe; Snufsjuka* (Swedish); *Qual-Tong* (Chinese). Many other synonyms, grave and humorous, might be listed which have been suggested by the peculiarities of various epidemics, the national characteristics of the people affected, or some fancied resemblance of the symptoms, but influenza, la grippe, or the Anglicized grip, have practically superseded all other names, in medical as well as lay circles.

Influenza is of Italian origin, and was probably first employed by the Italian savants to indicate the supposed occult influence of the stars over the course of the disease. Wolff states that it was first used by an Italian author, Gagliardi: "Parere sopra l'influenza catarrale, che presentamente regna in Roma e Stato ecclesiastico, Roma, 1733." Other authorities, however, trace its origin to the English writers Pringle and Huxham, the latter of whom, in describing the epidemic of 1742–43, writes: "Quæ per totam Europam hoc vere sub nomine influenza grassata est."

The derivation of *la grippe* is likewise in doubt. Most authors refer its origin, and probably correctly, to the French, *agripper*, to seize, but others derive it from the Polish, *chrypka*, or *grypka*, hoarse. It came into general use in France during the epidemic of 1732 (Marigné).

Historical Sketch.—Since the appearance of the first edition of this Reference Handbook, containing the brief article on *Influenza*, a series of epidemics has swept over the world, which, for rapidity of movement, extent of distribution, and numbers affected, rivals all previous visitations of the disease. This series, which began in the fall of 1889, was the first general epidemic of influenza since 1847–48, and really introduced the present generation of practitioners to a disease known to them only in history, and thus became one of the notable medical events of the latter half of the nineteenth century.

Recurring at a time when the study of the infectious diseases was being pushed so zealously along bacteriological lines, and engaging in its study the ablest clinicians of every nation, it was confidently predicted that the mysterious problem of its nature and etiology would be speedily solved. This prediction has been fulfilled and our knowledge of epidemic influenza now rests on a foundation of carefully recorded facts.

In this necessarily brief historical sketch we shall not attempt a complete chronological account of the epidemics of all ages, but shall allude only to those which, from special incidents, mark an era in the progress of our knowledge, and endeavor to trace somewhat in detail the course of the recent epidemics of 1889–92. Since then influenza has been endemic in most countries of the world. The presence of bacillus-carriers is the probable explanation of this endemicity.

Medical historians have interpreted the vague utterances of Hippocrates and Livy, referring to a disease which assumed epidemic proportions in 412 B.C., as the first written allusion to influenza.

Mention is made of an epidemic which prevailed extensively in the latter part of the sixth century, in which the prominent symptoms were headache, debility, cough, and an irresistible desire to yawn. Sneezing was usually the first symptom of the prevailing distemper, and the custom of calling down "God's blessing" upon one who was heard to sneeze is said to have originated at this time.

It is very probable, as maintained by many authors, that not a few of the general epidemics described in the earlier medical chronicles under various names (catarrhal fever, Italian fever, etc.) were epidemics of true influenza.

Parkes traces the disease back to the ninth century. In 827 and 876 epidemics in which cough was the most prominent symptom, and which also extended to domestic animals and birds, originated in Italy and spread rapidly over all Europe. The epidemic of 876 is said to have sadly discomfited the victorious army of Charlemagne on its return march from Italy.

But one epidemic, and that limited to Germany and France, is known to have occurred in the tenth century, after which the world apparently enjoyed immunity for about two hundred years.

Whatever may have been the nature of these early epidemics, our positive knowledge of influenza, according to Wilson, dates from the great visitation of 1510, which covered the whole of Europe and the British Islands, and was so general that "not a single family and scarce a person escaped it."

The epidemic of 1557, which appeared suddenly in Eastern Asia and spread rapidly to the West, was the first influenza epidemic which is known to have crossed the Atlantic to America. This pandemic was very severe in certain localities and was attended with a high mortality. Five thousand are said to have died in Delft alone within a short period.

During the past four hundred years there have been about seventy epidemics of grippe, one-half of which, from their widespread prevalence, deserve to be called pandemics.

The nineteenth century had thirteen visitations; the last important one previous to 1889 was that of 1847, in which were stricken more than one-quarter the population of London and Geneva, and fully one-half that of Paris. The course of the later epidemics has been quite uniformly from east to west. It is, of course, only the general trend of the epidemic that can be followed, since every locality invaded becomes at once a new center from which arms of infection reach out in every direction. With few exceptions, the later pandemics of influenza originated in Eastern Asia, where the disease may be said to be endemic. From this nidus they travelled westward across Russia thence over continental Europe and the British Isles, over the ocean to America, Australia, East Indies, until, like Puck's girdle, they circled the globe.

The great pandemic of 1889–90 followed closely the beaten path. The first cases of which we have knowledge occurred in Bokhara, Central Asia, in May, 1889. The disease became prevalent in July, and following the lines of the new railways slowly invaded other portions of the Russian empire. It can be easily traced through Western Siberia and the post-towns and stations in Russia in its march toward St. Petersburg, which was reached by the end of October, and two weeks later it had assumed such startling proportions in that city as to attract the attention of the civilized world.

From St. Petersburg the epidemic spread with unprecedented rapidity, and the cities of Western Russia, Central and Northern Germany, Austria, France, and the British Islands, became in turn, the scene of its ravages, until by the end of December it had compassed the whole of Europe. Scattering cases announced the appearance of the disease in New York about the middle of December, and a week later it had assumed epidemic proportions. From the seaboard it extended in every direction, and during January, 1890, was generally diffused over the United States, British North America, the Sandwich Islands, and Central America (Guatemala).

From its starting-point in Central Asia the epidemic also extended in a southeasterly direction. Malta, Cyprus, and Egypt were successively visited in January and February. It was reported from India in

February, became epidemic in March, and prevailed extensively in Upper and Lower Burmah during April and May. It reached Arabia in April, many of the pilgrims arriving from India and the Straits having sickened on the voyage.

In the Southern hemisphere the course was from the south northward. Cape Town was the seat of its first appearance in Africa, it having been carried thither by steamers; thence it extended northward, reaching Mauritius in August, the Shire Highlands in September, and Abyssinia in November, 1890.

South America was reached in February. Buenos Ayres was infected presumably by steamer from Bordeaux; thence it travelled up both coasts and prevailed in Brazil, Chile, and other states during April and May, and was notably severe in the province of Pernambuco. It was prevalent in Australia and New Zealand from March to July.

In Iceland it occurred in July, and in some remote places of China and Kashmere during September and December.

Dr. Parsons, in his exhaustive report to the British Medical Association, July, 1891, to which we are largely indebted for the facts above related, writes: "Thus assuming the epidemic to have started from Russia in October, it took about six weeks or two months to spread over Europe and reach North America, rather more than two months to reach the Cape, three months to reach South America, four months to reach India, five months to reach New Zealand and Australia, nine months to reach Iceland, ten months to reach Mauritius, and nearly a year to make some remote places in Africa and Asia."

During the summer and fall of 1890 influenza was "smouldering on," as shown by the numerous local outbreaks, usually of short duration, in different parts of the world.

The second general epidemic—1891—began in January, and was but little less extensive and probably more fatal than the one just sketched. It, too, was pandemic, but in the journey around the world the course of its predecessor was reversed, and the general trend was from west to east.

The origin is traced to New Orleans, where influenza prevailed extensively and fatally in January, and from which it radiated in every direction. During February, March, and April it spread over the Northern States and was notably severe in Pittsburg and Chicago (March) and the seaboard (April). It was reported from England in April, from Germany in August, from Scandinavia and Denmark in July, from Russia (St. Petersburg) in September, from France in October, from Italy in December, and thus passed from country to country until almost the whole civilized world had been revisited. This epidemic also ran its course in about one year.

Since 1889 each winter has brought a recurrence of epidemic influenza, varying in extent and severity, to all parts of the world. Few American cities have escaped an annual visitation.

Nature and Etiology.—Influenza was formerly regarded as an epidemic catarrhal fever, but the belief now prevails that it is really an infectious nervous fever. Many of the symptoms are most readily explicable upon a neural basis, while its bacterial origin, together with the knowledge of the toxemias that usually attend upon bacterial infection, gives support to such an explanation. Much testimony has accumulated during the recent epidemics to show that the nervous symptoms are primary and are followed by secondary involvement of the respiratory and digestive organs. In a given case the pulmonary, gastrointestinal, or cerebrospinal symptoms predominate as the nervous apparatus of one or the other system bears the brunt of the disease.

Nervous symptoms are uniformly present and usually pronounced, even in the mildest forms of grip, while, on the other hand, in many of the worst cases, catarrh of the mucous membranes and inflammation of the respiratory tract are notably absent.

Again, when catarrh and pneumonia are present, they frequently assume "such a peculiar character as to lead to the suspicion that they might arise from irritation of, or loss of power in, the various nervous mechanisms supplying the affected parts, and would therefore have to be looked upon more as vasomotor and trophic neuroses than as ordinary catarrh and inflammation."

The histories of the various epidemics prove clearly that the disease is not dependent upon climate, soil, season, meteorological, or electrical conditions. It affects all classes of people, irrespective of nationality, sex, social position, or environment, although infants and young children seem to possess partial immunity. While no season of the year is exempt, late autumn and early winter are the periods of its greatest frequency.

The phenomena of influenza are comprehensible only upon the theory of a specific infecting virus or germ as the exciting cause. Its epidemic occurrence, transmission along lines of travel, rapid diffusion, sweeping over whole continents in a few weeks, and affecting nearly the entire population in a certain district in a few hours after its appearance, indicate some powerful morbific agent in the atmosphere which acts specifically upon the animal economy.

For long the pathogenic bacillus eluded the vigilant search of bacteriologists.

The bacillus isolated by R. Pfeiffer in 1892 from the nasal and bronchial secretions is now conceded to be the cause of the disease. Some authors, however, teach that there is no such clear-cut, definite importance attached to its presence in secretions as in the case of the gonococcus, tubercle and typhoid bacillus (W. H. Smith).

Pfeiffer's bacillus is a tiny rodlet 0.8 to 1 μ long and 0.1 to 0.2 μ broad, about the same thickness and half the length of the bacillus of mouse septicemia. It is the smallest bacillus yet isolated, and in cultures is recognizable during the first twenty-four hours only by means of a lens, so that macroscopically a test-tube containing them can scarcely be distinguished from a sterile one. They are, however, readily differentiated by the peculiarity of their growth, as the colonies always remain separate and do not, like the colonies of other bacteria, join together and form continuous rows. When neighboring colonies come together the contours of the several colonies remain recognizable. Under the microscope they show a peculiar glassy transparency and are almost structureless.

The influenza bacilli are stained with difficulty. They respond either to a dilute Ziehl-Neelsen solution of carbol fuchsin or to a hot Löffler methylene-blue solution, and more deeply at the ends than in the middle so that they appear not a little like diplococci. They do not stain by Gram's method.

The bacilli have been found in large numbers in sputum, bronchial, pleural, and pneumonic exudations, and in the blood (Canon). Horder (1905) has cultivated them from cardiac valvular vegetations following influenza. They are present in such enormous numbers in the sputum of influenza patients that the bacteriological diagnosis is ordinarily a simple problem. They persist often after the severe symptoms have subsided.

Inoculation experiments have been negative in most species of laboratory animals but Cantani has succeeded in producing in rabbits a fatal form of influenza with profound nervous systems, by the intracerebral injection of living bacteria. And, contrary to the usual result of inoculations, the specific bacteria were found increased not only at the local seat of infection but also in the circulating blood and in remote organs. Guinea-pigs are susceptible to a fatal infection but the required dose varies largely. Pfeiffer and Beck caused

the disease in monkeys by rubbing their nasal mucous membranes with pure cultures.

It is highly probable that the action of the morbific principle of grip is not limited to man. Epizoötics, very similar in many respects to the epidemics in the human race, have often prevailed among domesticated and wild animals, especially horses, dogs, and cats.

The attention of the profession was first called to this fact by Huxham in connection with the epidemics of 1732–33. These epizoötics occur independently, but more often happen either simultaneously with or immediately precede or follow epidemics of influenza. Bartholow favors the view that the epidemic disease in animals is the parent of that in man, but is so modified by transition that each succeeding epidemic is milder and less aggressive. Osler denies that animals are susceptible of infection by the influenza bacilli.

On the other hand, Strümpell concedes that horses are attacked, but doubts whether all of the diseases in animals attributed to influenza are identical with the human disease.

The contagiousness of influenza was long a mooted question. The belief that contagion is the most important if not the only method of propagation has, however, been strengthened by numerous observations made during the recent epidemics and is now accepted by most clinicians. The source of infection lies chiefly in the nasal and bronchial secretions.

The frequency with which epidemics, both in their general and in their local distributions, follow the regular lines of travel, the immunity of isolated households and communities, and the frequency with which local outbreaks have been traced to their sources leave, indeed, little room for scepticism. It has been abundantly proved that the spread of influenza is not materially affected by the direction of the prevailing winds; and, in fact, some recorded observations indicate that it may even travel more rapidly against than with the wind. The marvelous rapidity with which influenza sometimes spreads in a community once infected is readily accounted for by its remarkably short period of incubation. It is claimed by many that personal contact with infected individuals or materials is the only method of its propagation. The supporters of this doctrine contend that the dissemination of disease germs through the air must have its limitations. That they can be carried thousands of miles in air currents without dispersion or destruction, or the assumption, on the other hand, of proliferation in the air itself, does violence to our knowledge of the life history of disease germs. There are, however, too many irregularities in the behavior of grip epidemics, not necessary to be enumerated here, to permit us to accept personal contact as the only factor in its propagation. Hirsch has pointed out that notwithstanding the modern facilities of intercommunication and rapid transit, epidemics do not travel more rapidly than modern methods of conveyance.

The passengers and crews of ships which have sailed from non-infected ports, and have held no communication with other ships, have been, according to many authorities, repeatedly attacked in mid-ocean.

The following striking instance is related by Sir Thomas Watson: The frigate *Stag* anchored at Berry Head, on the Devonshire coast, all on board well, April 3, 1833, the very day on which Watson saw his first cases of influenza in London. The breeze was off the land, and in half an hour after dropping anchor forty men were down with influenza; six hours later the number was increased to sixty, and soon reached one hundred and sixty. Smith in "Forchheimer's Therapeusis of Internal Diseases" quotes Parsons to the effect that of thousands of persons "engaged in deep-sea fishing on Dogger Bank or Skilling Bank, North Sea, not one is known to have contracted influenza at sea; the few outbreaks occurring commenced two or three days after leaving port, or, in one case, after communication with another vessel."

The period of incubation is very variable, both in individual cases and in different epidemics. It may develop almost immediately after exposure, from which it has received one of its popular names, *Lightning Catarrh, Blitz-Catarrh;* but in other instances there is an incubation period lasting from a few hours to several days.

Dr. Goodhart has recorded some startling instances of the suddenness with which strong men engaged in their ordinary vocations were stricken with the disease.

Influenza is no respecter of sex or age, though males between the ages of twenty and fifty years seem most susceptible to the infection.

One attack does not confer immunity from subsequent ones, and a few persons even experience a second seizure during the same epidemic. An epidemic, as a rule, lasts from four to eight weeks in a given locality, although many run a shorter course and often end as suddenly as they began. The rate of progress varies greatly, not only in different epidemics but also in the same epidemic as it spreads over different districts.

There is no causative relation between influenza and other epidemic or infectious diseases. The statement that prevalent infectious diseases abate in frequency and intensity upon the appearance of grip is not sustained by facts. Neither is there any ground for the popular belief that cholera follows in its wake. In some instances, notably in 1831, 1847, and 1856, the two diseases have been closely associated in point of time, but the official report of the French commission fully indorses the conclusion of Gluge and Smolensky that the association was purely accidental.

Morbid Anatomy.—The anatomical lesions found after death give meager information as to the pathology of influenza. A fatal termination is almost invariably due to complications, and the structural changes found post mortem are characteristic of the secondary disease, and not of influenza. Death rarely occurs in uncomplicated cases. The lesions peculiar to influenza are almost exclusively localized upon the respiratory mucous membrane. The mucous lining of the larynx, trachea, and bronchial tubes is hyperemic, swollen, and covered with frothy or viscid muco-pus. The catarrh may extend to the finer bronchi, but is ordinarily limited to the trachea and larger tubes. The bronchial glands are sometimes enlarged and softened. The gastric and intestinal mucous membrane is more or less congested in a considerable portion of the cases. The solitary and agminate glands of the intestine are not usually implicated. Kernig, of St. Petersburg, found the spleen enlarged in all cases which came under his care.

Symptoms.—The complexus of symptoms of influenza is exceedingly varied, and this variability extends not only to different epidemics, but also to individual cases of the same epidemic. In many cases the attack closely resembles an ordinary catarrh, with little fever and slight hyperemia of the nasopharyngeal mucosa; again, it assumes the form of an intense infectious fever, with profound involvement of the nervous centers, while between these extremes are found cases of almost every grade of severity, and almost every combination of symptoms.

Many attempts have been made satisfactorily to classify the protean forms of the disease. The classification most generally followed by recent writers is a modification of that long ago proposed by Hufeland: (1) The catarrhal or respiratory type. (2) The nervous type. (3) The gastrointestinal type.

It is estimated that in recent epidemics about fifty-five per cent. of the cases belong to the nervous, thirty per cent. to the catarrhal, and fifteen per cent. to the gastrointestinal form of the disease. These estimates will undoubtedly have to be changed for different localities. According to the observation of the writer, nervous symptoms predominated in about eighty-five

per cent. of the cases in the epidemic of 1889-90, while in that of 1891 the catarrhal and gastric forms were more common and severe, but still constituted a small percentage of the cases. The division is, however, purely arbitrary, and finds its chief value in emphasizing the fact that the brunt of the attack may fall upon any one of the three great systems.

The catarrhal type of influenza usually begins abruptly, but is occasionally preceded by a feeling of indisposition or malaise of from a few hours' to several days' duration. A distinct chill or, oftener, a mere chilliness is at once followed by a rise of temperature and the symptoms of a nasopharyngeal catarrh, with cough, sore throat, frontal headache, pains in and general soreness of the limbs, depression of spirits, and sometimes gastrointestinal disturbances.

The fever is remittent in type, variable in intensity, rarely exceeds 104° F. in uncomplicated cases, and subsides by lysis, rather than by crisis. As a rule, the temperature reaches its maximum at the beginning or early in the attack, and often drops below normal during convalescence.

A subnormal temperature has been noted in many epidemics, accompanied usually by surface coldness, feeble circulation, and other evidences of depression. The later epidemics were peculiar in the large number of cases in which the fever took on a continuous type, and peristed for two or three weeks, resembling in many of its features a mild typhoid fever.

The pulse is moderately increased in frequency and changeable in rhythm and quality. The tendency to cardiac asthenia, so pronounced in grave cases, often becomes a serious menace in those of moderate severity. An extraordinary slowing of the pulse is sometimes observed. The pulse may register only in the forties or fifties and naturally excites fears of some cerebral complication. This abnormal retardation belongs to the natural history of certain rare types of the disease, although it is often erroneously attributed to remedies, especially if digitalis or other cardiac sedatives have been administered.

Coincidently with the fever, and sometimes preceding it, the symptoms of an acute catarrh of the upper air passages are manifested.

There are frequent paroxysms of sneezing, a feeling of stuffiness in the head, the eyes are suffused and watery, and coryza with an abundant secretion of mucus speedily follows. The mucous membrane of the nose, mouth, frontal sinus, pharynx, and larynx is congested. The voice becomes hoarse or reduced to a whisper. Cough is rarely absent, usually severe, and recurs in paroxysms which harass the patient day and night. At first it is harsh and brassy and attended with a scanty muco-serous expectoration, which, as the disease progresses, becomes abundant, mucopurulent, and often blood-streaked.

Sharp pains in the sides and under the sternum, dyspnea, and suffocative paroxysms are experienced, and, as was long ago pointed out by Graves, of Dublin, often without any recognizable intrathoracic lesion. The catarrhal process does not, as a rule, extend below the larynx or trachea, but if it should invade the lower air passages, the deepening of the symptoms at once announces the fact and the illness assumes a more serious aspect.

Nervous Type.—Nervous disturbances are uniformly present in all forms of influenza but vary greatly in intensity. In some epidemics, notably in 1889–90, they predominated over all other symptoms. Severe headache, usually frontal, and pain in the eyeballs are rarely absent. The head pain comes on suddenly, is nearly continuous, dull, and throbbing, with frequently recurring paroxysms of atrocious severity. It is exaggerated by pressure or movement, and is often associated with hyperesthesia of the scalp and neck.

With the headache there is stiffness and soreness over the entire body, as if it had been beaten, and a backache which in its intensity is suggestive of dengue or smallpox.

The patient either lies perfectly quiet, to prevent the suffering which the slightest movement causes, or tosses restlessly about in the futile effort to find a position of comfort. Sharp neuralgic pains dart along the principal nerve trunks, but show a decided preference for the trigeminal, intercostal, lumbo-abdominal, and sciatic nerves. These neuralgias are often intermittent, but do not exhibit the periodicity of ordinary malarial neuralgias. Neuritis in varied forms is not uncommon.

Persistent insomnia or unrefreshing snatches of sleep filled with painful dreams add to the patient's distress. Delirium of a mild type is usually present, and is often marked when the fever is slight. In exceptional cases it becomes so furious as to overshadow all other symptoms. Coming on late in the disease it often announces the onset of some complication.

Vertigo, especially on rising, and muscular tremor are not uncommon. Convulsions and coma are rare, but in the severer forms of the disease may develop with the initial fever or at any subsequent period. Cases of influenzal cerebrospinal meningitis have been recently reported by Flexner, Wollstein, Dunn, and others. It may occur with or without the usual infections of the respiratory tract. It affects children more often than adults and is uniformly fatal. Flexner (1911) reports that Wollstein has experimentally produced in monkeys a severe cerebrospinal meningitis by injecting into the subdural space virulent cultures of *Bacillus influenzæ*. The disease thus caused is precisely similar in its clinical and pathological sequence to the spontaneous disease occurring in human subjects.

The hopeful note is found in the statement that it has been possible to rescue monkeys regularly from the fatal effects of an artificially produced cerebrospinal meningitis by the subdural injection of an immune serum prepared in the goat by the continued injection of virulent cultures of the influenza bacillus.

The extreme muscular weakness, anounting at times to a serious depression of the vital powers, is a peculiar feature of influenza. The debility is wholly disproportionate to the amount of fever or the severity of other symptoms, and generally reaches far into convalescence.

The mental condition harmonizes with the physical depression. When thoroughly under the grippe influence, the patient shrinks from mental as he does from physical exertion, is vacillating, foreboding, and often becomes a veritable "Jacques" in his melancholy.

While restlessness and wakefulness characterize most epidemics, others are equally marked by somnolence. Thus the remarkable epidemic of 1712 is known as the *sleeping sickness*, from the almost universal presence of this symptom.

Gastrointestinal Form.—The disturbances of the digestive organs are generally mild and consist of anorexia, coated tongue, epigastric tenderness, abdominal pains, and constipation. The tongue is heavily furred, flabby, deeply indented by the teeth, and tremulous. The breath, as a rule, is peculiarly offensive. Nausea and vomiting sometimes usher in the attack and may continue throughout its course. At times the force of the disease is expended in the intestinal tract and causes severe colicky pains, tympanites, and obstinate diarrhea. The stools, at first bilious and fetid, soon take on a dysenteric character or become larger and watery, like the discharges of cholera nostras, and are accompanied with vomiting, leg cramps, and rapid prostration. In the Paris epidemic of 1830 the cramps and intestinal troubles were marked and closely resembled Asiatic cholera (Dieulafoy). The digestion remains impaired for some time after the subsidence of the acute symptoms, and not only retards convalescence, but favors a return of the gastrointestinal derangements upon the slightest indiscretion of diet.

The urine is scanty, high-colored, and contains abundant urates. Albumin and casts, hyaline and epithelial, are present in a limited a number of cases not necessarily of the gravest type. The integrity of the kidneys is rarely permanently impaired. Cystitis is sometimes met with, and retention of urine in elderly persons is tolerably common.

The presence of a hemorrhagic tendency has been remarked by many observers. Epistaxis and menorrhagia are the most, and cerebral hemorrhage the least common of the accidents dependent upon this tendency.

Eruptions are occasionally seen, of which herpes, urticaria, and erythema constitute the chief examples.

The disease attains its height on the second or third day and then rapidly declines, covering a period of from four to seven days in its full evolution; but in the graver cases, or in those disturbed by complications, recovery may be indefinitely delayed.

Convalescence is often announced by the appearance of some critical discharge, such as profuse sweating, a copious secretion of bronchial mucus, a free discharge of sedimentary urine, or a profuse diarrhea.

After complete apyrexia has ensued, there is not infrequently a temporary return of the fever and other symptoms not dependent upon the presence of a complicating disorder. This new outbreak is usually of brief duration, and should be considered an exacerbation rather than a relapse. It is apt to appear on the fifth or seventh day of the disease, and is oftenest seen in those who have committed some error of diet or have undergone some exposure. True relapses are, however, not uncommon or free from danger.

Complications and Sequelæ.—While there has been a tendency to exaggerate the frequency and importance of the complications and sequelæ of influenza, the fact remains that there is scarcely another disease so liable to intercurrent disorders or to serious after-effects. The more common of these are divisible into two groups: First, those which are the direct outgrowth of the lesions in the mucous membranes and parenchymatous tissues; and, second, the sensory-motor derangements, which result from the action of the grippe toxin upon the cerebrospinal centers. Among the rarer affections belonging to the first group may be mentioned circumscribed ulceration of the vocal cords, abscess of the larynx, edema of the glottis, and paralysis of the muscles of the throat.

Otitis media is comparatively common. The inflammation does not, as a rule, proceed to suppuration, but is rebellious to treatment and occasionally ends in mastoiditis. In fact, more cases of mastoid disease requiring operation are attributed to influenza than to any other constitutional disease. It is worthy of remark that the pain in the mastoid region is often comparatively slight even when the local disease is extensive and severe.

Bronchitis and pneumonitis are by far the most frequent and fatal complications of this group. Authors have endeavored to show that these affections, when associated with influenza, are peculiar in nature and symptomatology. According to Elliot "the grip-lung has a long and varying condition of passive blood stasis unaccompanied by râles. If resolution occurs within three or four days, it is accompanied by large mucous râles, and no time is given for the slow appearance of bronchial breathing or bronchophony; but during the long continuance of the blood stasis an exudation occurs, increasing slowly, which will give in time some bronchophony and bronchial breathing, but never so complete as in pneumonia. Resolution never occurs in these cases with the suddenness that characterizes it in acute pneumonia. The condition passes off as gradually as it is formed. The sharp, clear-cut, and sudden phases of the pneumonia attack separate it clearly from the obscure, irregular, and slow phases of the grip-lung."

Da Costa, in a clinical lecture, describes the characteristic influenza lung as one "in which intense congestion occurs, with patches of collapse and with spots of localized consolidation here and there, if consolidation happen at all. Yet there are instances in which real croupous pneumonia takes place, involving considerable portions of the lungs. But these are comparatively rare, and true lobar pneumonia is not nearly so characteristic of the influenza lung as the other form."

Osler, with whom the writer is in full accord, admits that pneumonitis complicating influenza sometimes runs an atypical and very obscure course; but these cases are exceptional, and all the anomalies mentioned by writers as peculiar to influenza are found in any large series of cases of pneumonia.

It is highly important to bear in mind what has been previously stated, that lung complications are liable to creep on insidiously, and that in the presence of anomalous symptoms, whether referred to the respiratory tract or not, the chest, as a matter of routine, should be carefully interrogated. Pleurisy and empyema are not uncommon complications. As a matter of fact, when pleurisy occurs it is apt to take on the suppurative form. Abscess of the lung has been noted. That influenza bears an etiological relation to phthisis pulmonalis, especially in the presence of the disposition, can no longer be doubted. It is furthermore a matter of common observation that consumptives fare badly during the prevalence of the epidemic influence.

Watson and Curtin call attention to the fact that in certain epidemics many chronic catarrhal cases in which the lungs were involved resembled closely and were often mistaken for phthisis. There were present night sweats, cough, diarrhea, fever, and emaciation, while the physical signs also agreed with those of phthisis in all but dulness on percussion, which was absent. These writers, in speaking of the relationship between phthisis and influenza, make the following remarkable statements: "The catarrhal condition remains and causes a breaking down of lung tissue. These cases, while presenting the physical signs of phthisis and terminating finally in death, showed during life, on examination of sputum, no bacilli. In the fall of 1890, in the Philadelphia Hospital, the sputa of fourteen cases of phthisis examined (several times and by different methods) for bacilli showed them abundant in four, few in six, absent in four cases. In the fall of 1891, after most of the old cases of phthisis had died, twelve out of twenty-eight cases were found free from bacilli, and invariably with histories dating from an influenzal attack."

Cardiac disturbances both organic and functional are noted. Cases of endocarditis have been reported in which, at autopsy, influenza bacilli have been isolated. Pericarditis is apt to be latent. Myocarditis is a recognized cause of death.

Thrombosis, both arterial and venous, is not rare either as a sequel or as a complication. Leyden and Guttmann collected twenty-eight cases of phlegmasia alba dolens.

The nervous disturbances which occur during and after grip are equally important.

Althaus reflects the opinion of neurologists in the statement: "That as a powerful etiological factor of protean forms of nerve disease influenza stands *facile princeps* among all infectious fevers."

The organic nervous diseases most frequently observed may be enumerated, in the order of their frequency, as neuritis, meningitis, myelitis, and cerebritis.

Multiple neuritis is less common than the local forms, of which latter neuritis of the supraorbital, intercostal, and sciatic nerves is oftenest met. But "isolated neuritis of almost every cranial nerve has been recorded with such resulting conditions as optic atrophy, loss of smell and taste, ophthalmoplegias, both internal and external, oculomotor, facial, bulbar,

and pseudobulbar palsies of various types, including true pneumogastric paralysis" (Mills).

Leptomeningitis (pia-arachnoid) and cerebrospinal meningitis are the commonest types of meningeal inflammations.

Bristowe has reported two cases of cerebral abscess, and has seen others in which the symptoms would justify such a diagnosis.

Convulsions have been repeatedly observed, and in a few instances the epileptic habit has been permanently established. Mills has seen two cases.

Poliomyelitis anterior is the form of spinal-cord disease most frequently associated with influenza. Temporary paralysis of one or more limbs, evidently of spinal origin, is occasionally seen. Abolition of the patellar reflex has been noted.

Neuralgic attacks, severe, persistent, and involving any of the nerve trunks are perhaps the commonest of the postinfluenzal neuroses. The rekindling of old and fading neuralgias during convalescence is another of the curious features of the disease.

Neurasthenia, both cerebral and spinal, hysteria and hystero-epilepsy, with their illimitable repertory of disease mimicries, are frequent sequels in certain epidemics.

Insanity is not rare. It usually takes the form of melancholia, with hypochondriacal or religious delusions and decided suicidal impulses. Leledy, Ladame, and others believe that influenza may act either as an exciting or as a prediposing cause, but that there is always an antecedent acquired or inherited predisposition. The onset is often sudden and bears no relation to the severity of the febrile attack. The insane are less disposed to contract grip than the sane, and its occurrence is sometimes attended by a remission in the mental symptoms. Althaus also recognizes as a rare postgrippal neurosis a peculiarly rapid—galloping—form of general paralysis of the insane, of which he has seen a few examples.

Biermer, Gottschalk, and others remark upon the frequent occurrence of severe hemorrhagic endometritis. In these cases the uterus is enlarged and sensitive, and the hemorrhage profuse. It has long been known that women sick with influenza were subject to profuse and painful menstruation. Pregnant women are liable to abort under the same conditions.

In conclusion, it is all important to bear in mind the tendency of influenza to develop latent into active disease. This is particularly noted in lesions of the heart, lungs, and kidneys. Under the baneful influence of a grip infection a slight albuminuria may be changed into a rapidly fatal nephritis, or a mild cardiac affection may speedily result in degeneration of the muscular walls of the heart with dilatation of its cavities, or a slumbering tuberculosis may be awakened into fatal activity.

Prognosis.—Uncomplicated cases of influenza end in recovery. The prognosis is modified somewhat by the character of the prevailing epidemic and the physical condition of those affected. Persons at the extremes of life and those debilitated by disease or vicious habits bear influenza badly. Infants are fortunately less likely than adults to contract the disease. The mortality is largely due to complications or to its development in those suffering from advanced pulmonary, cardiac, or renal affections.

Diagnosis.—Influenza is not likely to be mistaken in its epidemic form. The numbers affected, the fever, the catarrhal phenomena, the prominence of the nervous symptoms, and the rapid course will readily establish the diagnosis. Influenza bears a striking resemblance to non-specific catarrh caused by atmospheric changes, but it is only in those isolated cases which herald the approach of an epidemic that this similarity could mislead.

The only difficulty in diagnosis attaches to those cases occurring during the prevalence of an epidemic of grip in which coryza is absent and the symptoms are those of a general fever. Some of these cases closely resemble typhoid fever. The continued fever, delirium, epistaxis, diarrhea, and prostration are common to both, but the temperature charts and progress of the diseases are dissimilar.

In other cases the suddenness and violence of the onset, the variety and intensity of the nervous symptoms, and the irregular febrile movement are very like epidemic cerebrospinal fever.

Dengue and the nervous type of influenza have many symptoms in common, but the former is preeminently a disease of tropical climates. In our own country it is confined to the Gulf States and rarely extends beyond the thirty-second parallel. Only once (1780) has it reached as far north as Philadelphia. It was at that time described by Dr. Rush under the name of bilious remitting fever.

Prevention.—Little has been attempted in prophylaxis. It would, however, seem a wise precaution in severe epidemics to isolate, whenever practicable, those suffering from the disease, and to discourage the assembling of people in crowded public resorts.

But the nature of the pathogenic material and the remarkable rapidity with which influenza spreads—its whole career from inoculation to full development being only a matter of hours—will doubtless render abortive all attempts at quarantine.

It has been abundantly proved that during the prevalence of the epidemic influence those who are overfatigued or much exposed in the open air, especially at night, are more susceptible to the disease. The lesson to be drawn from this fact is obvious and should be heeded by the aged and debilitated.

Considerable testimony has been collected to show that vaccination with animal vaccine lymph furnishes immunity against influenza. Dr. Goldschmidt, of the Island of Madeira, was the first to call attention to this fact. The island suffered from a double invasion of smallpox and grip, and in investigating the relationship between the two diseases he ascertained that out of 112 persons successfully revaccinated not one contracted influenza; and of 98 in whom revaccination was attempted but failed, only 15 showed any symptoms of the disease. In an isolated villa there were 27 inhabitants, of whom 12 had been recently vaccinated. These all escaped, but the 15 who had not been vaccinated were affected. Althaus, who strongly advocates the protective power of vaccination, refers to illustrations which came to his knowledge, in which small clusters of recently vaccinated persons remained untouched, although surrounded by and freely mingling with grip-stricken people. The well-known immunity of children is attributed partially to the protective influence of vaccination. It is stated that in the German army, where revaccination is systematically enforced, influenza was less prevalent and less fatal than in civil life. While influenza affected forty-two per cent. of the population of Berlin, and about sixty-four per cent. of that of Paris, its prevalence in the German army amounted to only a little more than eleven per cent. A number of garrisons were entirely spared, while the inhabitants of the adjacent towns suffered severely, and it is further stated that no garrison was ever affected with influenza when the civil population escaped. When an outbreak did occur in a military post, it was found that those affected were almost exclusively soldiers who had not been recently revaccinated. And, finally, statistics show that the average duration of the disease is shorter, complications are less frequent, and the death rate is lower in military than in civil life.

Treatment.—Influenza is a self-limited disease of short duration. There is no specific. The researches of Cantani, Latapie, and Flexner afford ground for the hope that a curative vaccine, antitoxin, or serum may yet be discovered. A serum

prepared at the Rockefeller Institute, as stated elsewhere in this article, seems to be effective in the treatment of meningitis experimentally produced in monkeys by the injection of influenza bacilli. In view of the many severe complications and sequelæ which may arise, every case should be regarded as serious enough to necessitate confinement, at least within doors, until the fever has disappeared. Experience has demonstrated that those who remained in bed from the beginning of the illness not only appreciably shortened the attack but made a pleasanter convalescence.

Rest in bed, a mild calomel purge or saline draught, cooling drinks, an occasional Dover's powder to quiet cough, and the employment of such general hygienic and dietetic measures as are indicated in acute infectious diseases will meet every indication in simple uncomplicated cases.

In the futile search for a specific all of the leading remedies, new and old, have received an extensive trial. The coal-tar derivatives—acetanilide, antipyrine, and phenacetin have been extensively employed. They should be used with caution as profound prostration sometimes occurs after their employment. Phenacetin, from its greater safety and the absence of unpleasant after-effects, deservedly has the greatest popularity. Given early in the attack, it rarely fails to relieve the headache, lower the temperature, and lessen the muscular soreness and tired feeling. The writer has obtained excellent results from its combination with quinine or salol and caffeine. Stengel gives the following combination, the analgesic, antifebrile, and antiseptic properties of which commend it for routine use:

Salolis,	
Acetphenetidini . .	aa gr iii
Pulveris Doveri	. . . . gr. $\frac{1}{2}$
Ft. capsule No. 1.	
Sig. Repeat in two or three hours	

Salicin is an eligible remedy. It acts as a mild tonic, reduces temperature, excites perspiration, and relieves the gastrointestinal irritation. Its taste is objectionable. Quinine in medium-sized doses may be advantageously given throughout the sickness, but is especially indicated in the later stages and in delayed convalescence. When the head pain and muscular soreness are prominent the salicylate of cinchonidine is preferable to quinine, and is supposed to possess decided prophylactic powers. Strontium salicylate (gr. v. to xx.) is a remedy of great value and is better borne than the sodium salt. The insomnia, as a rule, readily yields to the bromides or veronal. The singularly depressing effects of grip on the mental and physical powers strongly contraindicate the use of lowering measures and remedies. Stimulants, preferably some form of ammonia or alcohol, should be resorted to on the first evidence of failing strength. In the presence of great thoracic distress or heart failure a timely use of the heart tonics, of which digitalis and caffeine are the best representatives, may avert the threatened danger. Strychnine alone, or in combination with tonics, is the most reliable drug with which to tone up the feeble heart so often left by grip.

Gastrointestinal irritation is best met with salicin, bismuth, preferably the subgallate, resorcin, and the salicylates.

Local applications to the inflamed respiratory mucosa add greatly to the patient's comfort and favorably influence the course of the disease. In the writer's experience nothing gives such grateful relief as the occasional spraying of the throat and nose with a weak solution (one to two per cent.) of cocaine and menthol in benzoinol or albolene. A gargle of boracic acid in glycerin and water soothes the irritation of the mouth and throat. Dobell's solution in the form of spray, or the inhalation of steam, pure or medicated with eucalyptus, creosote, or terebene, is of signal benefit in allaying the laryngeal and bronchial irritation. Troublesome cough is readily controlled by the old-fashioned Brown's mixture, or by small doses of heroine or codeine.

In the graver types of influenza, or when the course is anomalous, care must be taken not to overlook complications, which often, especially those of intrathoracic origin, steal on insidiously. These must be managed according to the principles of treatment laid down elsewhere in this Handbook.

Delayed convalescence, not uncommon after even mild infections, will call for a prolonged course of tonics, and, in many cases, for an outing at the seashore or in the mountains.

William Judkins Conklin.

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Infusa.—An infusion (*infusum*) is a liquid preparation made by treating vegetable substances with either hot or cold water. The drugs are not to be boiled, although boiling water is often employed. The United States Pharmacopœia gives the following formula for the preparation of any infusion the strength of which is not specified by the physician:

Take of

The substance, coarsely comminuted	50 gm.
Boiling water	1,000 c.c.
Water q.s. ad	1,000 c.c.

The strength of infusions of energetic or powerful substances should be specially prescribed by the physician.

The United States Pharmacopœia contains three infusions, the British Pharmacopœia contains twenty-two, and the National Formulary four.

		Composition.	Dose.
Infusum Aurantii (Infusion of Orange Peel).	B. P.	Dried Bitter-Orange Peel 50, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Aurantii Compositum (Compound Infusion of Orange Peel).	B. P.	Dried Bitter-Orange Peel 25, Fresh Lemon Peel 12.5, Cloves 0.25, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Brayeræ (Infusion of Brayera).	N. F.	Brayera 60, Boiling water to 1,000.	
Infusum Buchu (Infusion of Buchu.)	B. P.	Buchu leaves 50, Boiling water to 1,000.	1 to 2 fluidounces.
Infusum Calumbæ (Infusion of Calumba).	B. P.	Calumba Root 50, Cold water to 1,000.	½ to 1 fluidounce.
Infusum Caryophylli (Infusion of Cloves).	B. P.	Cloves 25, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Cascarillæ (Infusion of Cascarilla).	B. P.	Cascarilla 50, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Chiratæ (Infusion of Chiretta).	B. P.	Chiretta 50, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Cinchonæ (Infusion of Cinchona).	N. F.	Cinchona 60, Aromatic sulphuric acid 10, Water to 1,000.	
Infusum Cinchonæ Acidum (Acid Infusion of Cinchona).	B. P.	Red Cinchona Bark 50, Aromatic Sulphuric acid 1.25, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Cuspariæ (Infusion of Cusparia).	B. P.	Cusparia Bark 50, Boiling water to 1,000.	1 to 2 fluidounces.
Infusum Digitalis (Infusion of Digitalis).	U. S. P.	Digitalis 15, Alcohol 100, Cinnamon water 150, Boiling water 500, Cold water to 1,000.	8 c.c. 2 fluidrams.
Infusum Digitalis (Infusion of Digitalis)	B. P.	Digitalis leaves 6.8, Boiling water to 1,000.	2 to 4 fluidrams.
Infusum Ergotæ (Infusion of Ergot)	B. P.	Ergot 50, Boiling water to 1,000.	1 to 2 fluidounces.
Infusum Gentianæ Compositum (Compound Infusion of Gentian).	B. P.	Gentian Root 12.5, Dried Bitter-Orange Peel 12.5, Fresh Lemon Peel 25, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Gentianæ Compositum Fortius (Stronger Compound Infusion of Gentian).	N. F.	Gentian 125, Coriander 32, Bitter Orange Peel 32, Alcohol to 1,000.	4 c.c. 1 fluidram.
Infusum Krameriæ (Infusion of Krameria).	B. P.	Krameria Root 50, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Lupuli (Infusion of Hops).	B. P.	Hops 50, Boiling water to 1,000.	1 to 2 fluidounces.
Infusum Pruni Virginianæ (Infusion of Wild Cherry).	U. S. P.	Wild Cherry 40, Glycerin 50, Water to make 1,000.	60 c.c. 2 fluidounces.
Infusum Quassiæ (Infusion of Quassia).	B. P.	Quassia Wood 10, Cold water to 1,000.	½ to 1 fluidounce.
Infusum Rhei (Infusion of Rhubarb).	B. P.	Rhubarb Root 50, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Rosæ Acidum (Acid Infusion of Roses).	B. P.	Red-Rose Petals 25, Sulphuric acid 12.5, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Rosæ Compositum (Compound Infusion of Rose).	N. F.	Red Rose 13, Sulphuric acid 9, Sugar 40, Boiling water to 1,000.	
Infusum Scoparii (Infusion of Broom).	B. P.	Broom Tops 100, Boiling water to 1,000.	1 to 2 fluidounces.
Infusum Senegæ (Infusion of Senega).	B. P.	Senega Root 50, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Sennæ (Infusion of Senna).	B. P.	Senna 100, Ginger 0.25, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Sennæ Compositum. (Compound Infusion of Senna).	U. S. P.	Senna 60, Manna 120, Magnesium sulphate 120, Fennel 20, Boiling water 800, Cold water to 1,000.	120 c.c. 4 fluidounces.
Infusum Serpentariæ (Infusion of Serpentary).	B. P.	Serpentary Rhizome 50, Boiling water to 1,000.	½ to 1 fluidounce.
Infusum Uvæ Ursi (Infusion of Bearberry).	B. P.	Bearberry leaves 50, Boiling water to 1,000.	½ to 1 fluidounce.

R. J. E. Scott.

Infusoria. — *Ciliata. Ciliophora.* Protozoans bearing cilia and possessing two nuclei, macro- and micro-nucleus. Infusorians usually live in water where they subsist on various minute organisms and the débris from decaying organic matter. Some of them take up their abode in the alimentary canal of man and other animals. There they often multiply to such an extent as to irritate the intestine. See *Protozoa.* A. S. P.

Ingrassias, Giovanni Filippo.—Born at Rachalbuto, near Palermo, in the Island of Sicily, in 1510. He received the degree of Doctor of Medicine from the University of Padua, in 1537. Having shown himself to be a man of scientific attainments he soon received a call from the University of Naples to fill the chairs of anatomy and of the theory and practice of medicine. His instruction proved to be of such high order that pupils flocked to him in great numbers from every part of Europe. They erected in his honor a monument on which was inscribed the statement that he was the restorer of the true science of medicine and anatomy. In 1560, despite the fact that it was at Naples that he had acquired so much glory, he was impelled by the love which he cherished for his native land, to leave that city and return to Palermo. In 1563, Philip II., King of Spain and of Sicily, appointed him Chief Physician of Sicily and the adjacent islands, an office which he filled with such conspicuous ability (especially in 1575, when Palermo was visited by an epidemic of the plague) that public opinion conferred upon him the appellation of "Sicilian Hippocrates." The Senate of Palermo, furthermore, voted to bestow upon him, in requital of the valuable services which he had rendered to the people, a liberal pension in actual money, but he refused to accept more than a small portion of the sum voted to him, and that only because he wished to spend it on the embellishment of a public monument in Palermo. He is said to have been the first physician to recognize and describe scarlet fever. His death occurred on Nov. 6, 1580, at the age of seventy years.

The writer of Ingrassias' biography in the "Dictionnaire Historique de la Médecine" says that he discovered the existence of the stapes, the smallest of the three ossicles of hearing, and that he occupies a very high rank among anatomists for the minutely exact manner in which he describes the bones of the skeleton. His name is attached to the lesser wings of the sphenoid bone which are called the processes of Ingrassias. A. H. B.

Ingrown Toenail.—The condition of the toe called ingrown or ingrowing toenail is one with a misleading name which suggests that the innocent toenail is abnormal. From careful examination it has been established that the nail is a passive agent while the soft flesh on the side of the nail furrow is crowded up against the the harder nail usually by a tight shoe which squeezes the toes together until the flesh is cut into by the nail. It occurs almost exclusively on the big toe, and much less frequently on its free side than on the side toward the other digits where the smaller toes get underneath the great toe and push its soft flesh up against the edge of the nail as it curves downward.

The condition starts with a simple cutting of the nail fold by the edge of the nail, but the persistence of the pressure keeps the primary wound open and deepens it until hypertrophic granulation tissue grows up and deepens the wound still more. Infection, at least in a mild degree, is almost always present and may be active enough to threaten the patient with loss of toe, limb, or life just like any other infection. The laceration gets progressively worse as long as the causative factors of shoe pressure and infection are present. As a rule the patient on his own initiative relieves the shoe pressure, but when he tries to cut the nail he unfortunately usually makes the condition worse.

On examination we look at the shoes and note that they pinch the toes together because they are too narrow, too short, or with such high heels that the toes are crowded by the weight of the body into a narrow zone not intended for their support. On looking at the toenail we usually find that it has been pared away at the corner so that a sharper angle is left a little farther back to cut all the deeper into the flesh and worse still, so that when the nail grows out again it has to cut its way through the flesh that has grown up into the nail furrow. Frequently we note also that the nail is more curved or angulated than normal, this change in the shape of the nail also perhaps being due to the same lateral pressure on the toes. Digital pressure on the nail or under surface of the distal phalanx of the toe naturally greatly increases the pain by causing the nail edge to cut deeper. The hypertrophic granulation tissue in the nail furrow, the dried discharge and the evidences of infection in the toe and limb will be dependent on the grade of infection and the duration of the process.

The preventive treatment of ingrown toenail is not only the simplest and most satisfactory, but it is essential in that even after radical treatment the condition is apt to recur or to appear on the other side of the same toe or on the other foot unless the preventive measures are used. The essentials of prevention are: first, avoiding pressure that will bear on the sides of the toe by using footwear better adapted to the shape of the feet—longer, wider in the toes, or lower in the heel; and second, cutting the toe nail either straight across or so slightly curved that the nail, especially at its edges, extends beyond the flesh. If we notice we will see that the greatest width of the nail is attained where the nail becomes free from its matrix. In cutting the nail no futile attempt should be made to cut the free edge of the nail narrower than this greatest width until the nail is free beyond the skin.

In the early stages of the ingrown nail, which include the majority of the cases seen, several non-operative lines of treatment are very efficient when added to the proper footwear and care of the nail.

The application of the solution of chloride of iron under the edge of the toenail once a day cuts down the granulation tissue and controls the infection in many cases. If this is done on a little toothpick swab with which the soft tissues can be pressed away from the nail the condition may need no further treatment. The next simplest line of treatment is the application of a few drops of one per cent. cocaine on a pledget of cotton to the tender ulcer and then the insertion of a wick of gauze under the edge of the nail to press away the flesh. A bit of thick silver foil is preferable to the gauze because it gives a stiffer protection to the flesh and at the same time is permanently antiseptic. The bit of foil can be helped by a strip of adhesive plaster that starts on the flesh side and fold where the trouble lies and passing under the toe ends on the nail thus pulling the cut flesh away from the nail. The silver foil is over the adhesive strip and can be retained in position by a second bit of adhesive over the foil.

Webb uses a twisted silver wire some six inches long the middle of which he places under the free edge of

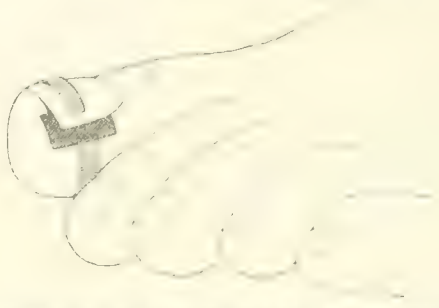

Fig. 3400—Silver Foil under Edge of Nail and Adhesive Strip, Both Enfolding Toe, Pulling Nail and Soft Tissues Apart

the nail, then carries one end around either nail fold to end over the base of the nail bed. The ends rest on a square bit of adhesive plaster which prevents their sticking into the skin and they are held down by a strip of adhesive that nearly surrounds the distal phalanx just back of the nail.

To these simple measures there can be added most efficiently a pad of cotton or wood, one-half inch wide, placed between the bases of the toes to prevent all pressure of the second toe on the great toenail.

Of the operative procedures there are two classes: those directed at the removal of the soft tissues only, and those involving the nail also. All of them can be done, as a rule, under local anesthesia with a tourniquet around the base of the toe.

Fig. 3401—Cutting Operation. Removal of Nail and Soft Tissues

The operations on the nail fold are the more rational; that of Cotting is one of the older and classical. He merely slices off the diseased fleshy parts together with a long thick slice of the adjoining healthy tissue at the side of the toe. The edge of the nail is exposed but not cut or injured. The wound is allowed to heal by granulation so that the cicatrix in the healthy tissue will keep the skin away from the nail.

Van Meter has devised a neater surgical procedure. He excises a diamond-shaped area of normal tissues at the side of the nail, carrying the incision down to the periosteum. The nail is not cut. The excision wound is closed by a linear scar pulling most at the diameter of the diamond which has been made opposite the point of injury. At times in order to get apposition of the edges of the wound it may be neces-

sary to nick the skin in the nail fold. The wound heals by primary intention and there is no mutilation.

The operations directed at the nail may be needed in some instances, but as the nail is only the passive agent in the condition unless combined with other measures these nail removals are also apt to be followed by recurrence. The simplest nail operation is merely evulsion of a portion, perhaps one-quarter of the width of the nail. One blade of a sharp-pointed scissors is pushed up under the nail well past the white lunule and through the matrix. Then the nail is cut through its full length. The nail on the diseased side is caught in an artery clamp, lifted away from the nail fold, and pulled out. Care must be taken that every bit of that segment of the nail comes away or the operation is worse than useless. The new nail may grow in the same place, but proper preventive treatment avoids the recurrence of the trouble. At the first dressing the toe is strapped with adhesive plaster to pull the soft tissue of the troubled nail fold away from the nail, by a strap running from the nail fold under the toe to end on the nail.

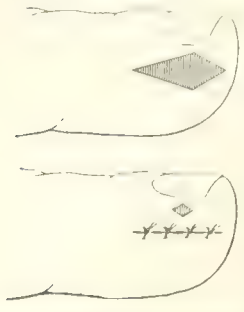

Fig. 3402 Van Meter Operation. Excision of diamond-shaped area of soft tissue on side of toe, with suture of wound so as to retract the nail fold.

The radical operation of von Bergmann makes a V-excision of the edge of the nail and the adjoining tissue. The incision is not carried through the plantar surface of the toe thus avoiding a scar that has to be walked on. In closing the wound the skin flap is left just long enough to come to the level of the nail matrix to which it is sutured so that there will be no prominence of the skin above the nail and therefore no nail fold to be cut into as well as no curved edge of the nail to do the cutting. The excision must extend far enough back to remove all the matrix of that section of the nail or else there will surely be recurrence.

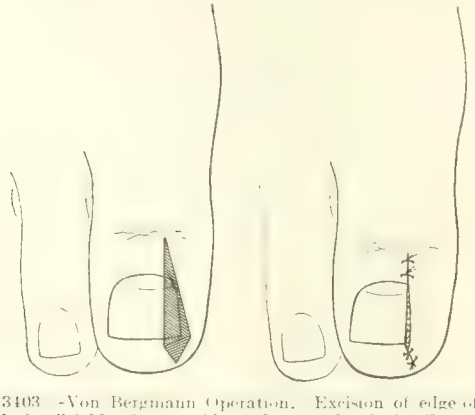

Fig. 3403 -Von Bergmann Operation. Excision of edge of nail and of nail fold. Suture of lateral flap at level of nail matrix.

In the conditions complicated by extensive infection the general treatment for the infection has to be associated with that of the local trouble.

Truman Abbe.

Inhalation is a method of administration of medicines chiefly employed in the case of the general anesthetics chloroform, ether, and nitrous oxide; but other agents are also used in this manner, notably amyl nitrite, oxygen, atmospheric air (modified as to conditions of temperature and pressure, or charged with some medicinal substance), steam, ammonium chloride, creosote, menthol, eucalyptus. The substance to be inhaled must be in the form of a spray, vapor, or gas, and the degree of penetration into the respiratory tract depends largely on the volatility of the substance. This method of medication is often of great value but, excepting in the case of a few drugs, it has fallen into disuse. The various forms of nebulizers, atomizers, vaporizers, and other apparatus used in the administration of inhalations may be found in special treatises on therapeutics and in the manufacturers' catalogues. Inhalations are used both for their *general* effect on the system (as in the case of the anesthetics and amyl nitrite) and also for their *local* effect on the upper part of the respiratory tract. For the methods and effects of the inhalation of chloroform, ether, and nitrous oxide the reader is referred to the article on *Anesthetics* in this Handbook. The use of amyl nitrite is one of the best instances of the value of this method of medication; the ordinary procedure being for the patient to crush in his handkerchief a pearl containing three or five minims of the drug and then to inhale the same. The effect is almost instantaneous, and is due mainly to the large absorptive surface of the lungs and the very thin membrane which separates the air in the pulmonary vesicles from the blood. R. J. E. Scott.

Inhibition.—The word "inhibition" is derived from the Latin *inhibitio*, meaning restraint. The term has often been employed loosely, however, depression, paralysis, and even narcosis having been considered as synonymous with it. Strictly speaking, inhibition in a physiological sense means the temporary retardation or cessation of a vital process as the result of the action of some agent, called a stimulus. This definition introduces us at once to the great question in the study of this subject, namely, how a stimulus, regarded as an *exciting* agent, can *retard* or *suppress* a vital process. It will be shown in the following review* of the literature of physiology that the search for the answer to this question has been prosecuted diligently, and with some success. Nevertheless, it is a curious fact that inhibition, now recognized as universal among living things, has received much less study than excitation. This is only natural, perhaps, for the latter shows itself in a positive way, so to speak, whereas, inhibition reveals itself only negatively, that is, as an absence of vital activity.

Historical.—It is difficult to ascertain who first conceived the idea that inhibition is an essential process in vital activity, but glimpses of this truth are revealed as early as 1662. R. Descartes,[28] in his "De Homine," while discussing willed movements suggested that lateral movements of the eyeball were made possible by vital spirits operating to cause tension in the external rectus and flaccidity in the internal rectus muscle. Thus, he imagined the mechanism producing relaxation to be a peripheral one (see Fig. 3404). Charles Bell,[5] with like remarkable prescience, pictured a peripheral inhibition in discussing the antagonistic action of flexor and extensor muscles. In speaking of the innervation of the eye muscles he says: "If we suppose that the influence of the fourth nerve is, on certain occasions, to cause a relaxation of the muscles to which it goes, the eyeball must then be rolled upward." This observation he made in 1823 (Trans. Roy. Soc. London). In 1838, A. W. Volkmann, a famous physiologist, clearly saw cardiac inhibition while looking for motor and sensory fibers in the vagus nerve. On stimulating the peripheral end of this nerve he saw the heart beat cease for a minute and a

* The references cited will be sufficient to direct the reader to the extensive literature on inhibition.

half. He considered the phenomenon very curious, but four years later stated that these vagal effects must have been due to an experimental error, and therefore they were invalid.[149] In 1845 or 1846 Budge[15] also saw vagal inhibition of the heart, but he explained the result as due to fatigue of a motor nerve. Then again in 1846, Claude Bernard observed by auscultation that the heart of a dog ceased beating when he stimulated the peripheral vagus. In that same year the credit for bringing the great fact of inhibition to

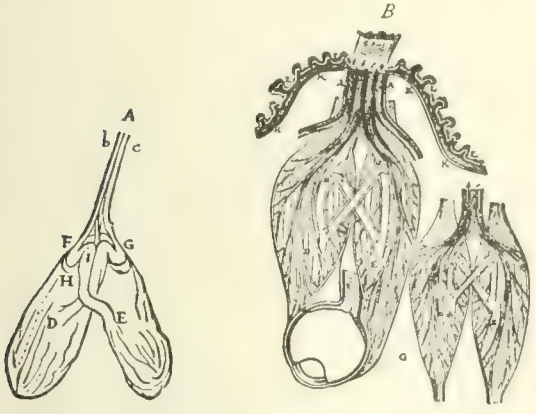

Fig. 3404.—Illustrations by Descartes (*A*, in 1662; *B*, in 1674) of His Conception of the Innervation of the External Eye Muscles. (Sherrington[134(b)]. Courtesy of Yale Press.)

scientific study went to the brothers E. H. and Ed. Weber,[153(a)] who published their observations on vagal inhibition of the heart, the fact having been previously announced by them at Naples in 1845. They[153(b)] used frogs, stimulating rapidly by electricity, one electrode being placed in the nostril and one on the cut surface of the spinal cord between the fourth and sixth vertebræ. The Webers were able to lessen both the rate and strength of the heart beat, and even arrest the contractions entirely. They also discovered the cardio-inhibitory center in the frog, locating it in the spinal bulb between the optic lobes and calamus scriptorius. By using the prick of a needle Eckhard[33] localized the center in the frog more exactly between the tip of the calamus and the cerebellum. By the same method Laborde[83] found this center in the cat at a point in the middle of the bulb in the lateral part of the floor of the fourth ventricle, a point which is approximately the seat of the center in all mammals so far investigated. It was known before the work of the Webers that the heart was also supplied by fibers from the sympathetic system. E. Weber considered that these fibers were motor fibers for the heart, but he was not able to prove this assertion.

The discovery of cardiac inhibition gave rise to a long controversy as to the exact nature of the phenomenon, especially when Pflüger[119] discovered the inhibitory action of the splanchnic nerve on the intestine, and when Rosenthal[130] announced the inhibitory action of the superior laryngeal nerve on respiration. There were those who contested the idea of inhibition very vigorously. Thus Schiff,[137] Budge, and Moleschott contended that the vagus was the motor nerve of the heart. For every example of inhibition an explanation was offered. It was a fatigue effect, an exhaustion of the nerve at the point stimulated (Budge), or it was the result of vasoconstriction, which lowered the irritabiltiy of the muscle (Brown-Séquard). Budge's theory was overthrown by the fact that a very weak stimulus, which could not fatigue the vagus, would stop the heart, and the vasoconstrictor theory was disproved by the failure of ligation of the coronary arteries to stop the whole heart quickly and completely. The difficulty in the case of the vagus was largely due to the fact that in the frog it contains accelerator fibers in a considerable part of its length; stimulation of this mixed nerve may produce inhibition or acceleration of the heart, depending upon the strength of the stimulus, the duration of its application, and the predominence of motor or inhibitory fibers. Bezold[8] (1862–66) cleared up the difficulty in part by discovering that in mammals the accelerator fibers leave the cord at about the level of the first thoracic vertebra; the brothers Cyon[27] (1867) demonstrated that these fibers pass to the stellate ganglion; and their further course was settled in 1871 by Ludwig and Schmiedeberg[185] who traced the fibers out in the dog. Schmiedeberg[139] about this time also contributed important facts on the paralytic action of nicotine, atropine, and curare on the vagus fibers in the heart. In the frog it was shown by Heidenhain[62] (1882) that the accelerator fibers come off from the cord below the vagus, which they later join. Bowditch[14(a)] (1873), and Baxt (1875) working in Ludwig's laboratory found that when the inhibitory and accelerator fibers are stimulated at the same time the inhibitory effect prevails. Finally, Gaskell[56] (1880–87) in investigating various forms—frog, toad, tortoise, and crocodile, showed that there is no essential difference in the innervation of the heart in cold- and warm-blooded animals.*

The distribution of the two sets of fibers within the heart, their mode of termination, and the nature of the intrinsic ganglia have long been matters of profound interest, but, withal, subjects difficult to investigate. Here may be mentioned an important contribution of Langley[85] and his associates who found that nicotine blocks the ganglionic connections between an efferent

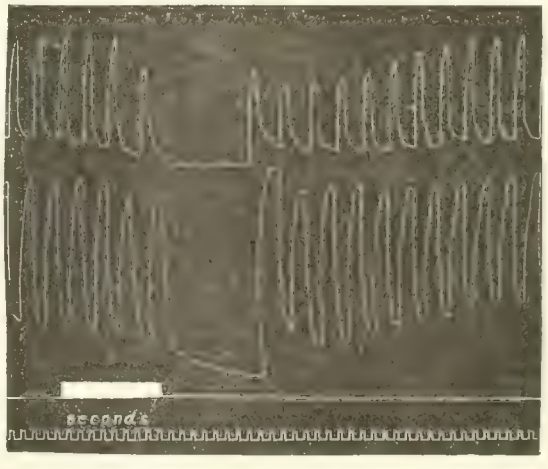

Fig. 3405.—Stimulation of the *Right* Vagus in the Terrapin (Chrysemys elegans, Wied.) Whole heart inhibited. Maximal ventricular contractions on resumption of beats.

nerve from the central nervous system and the succeeding peripheral neurone. By this means it was possible to show that the vagus fibers run as *preganglionic* fibers to the heart; there they come into relation with the intrinsic nerve cells of the organ; these cells send *postganglionic* fibers thence to the cardiac muscle. In the case of the accelerators, the postganglionic fibers take origin in an extrinsic ganglion (last cervical or first thoracic, or both).

The controversy alluded to above diverted attention from some important phases of vagus action as

*For further historical details see Meltzer: "Inhibition," N. Y. Med. Journ; 1899, May 13 and 27; Gaskel: "The Contraction of Cardiac Muscle, "Schafer's Text-book of Physiology, 1900, vol. xi., 169; O. Frank: "Hemodynamik." Tigerstedt's Handbuch der physiologischen Methodik, 1913, xi., 353.

described by the Webers. They had shown that the heart beats are weakened as well as slowed in the frog (their researches were extended to various other animals as well). It was not until 1868 and 1869 that the depressant action of the vagus was again brought to the fore. Donders[30] in 1868 described his study of the latent period of the vagus, producing the first careful work on that point. Coats[23] (1869) in Ludwig's laboratory studied vagal depression in mammals, and Nuël[113] (1874) noted that the contractions of the auricles were diminished more than those of the ventricles. Experiments were even performed upon man, for Thanhoffer[143] gives an account of compressing the vagus in the neck, with resulting stoppage of the heart and loss of consciousness. Gaskell and Heidenhain confirmed the observations of Nuël in 1881 and

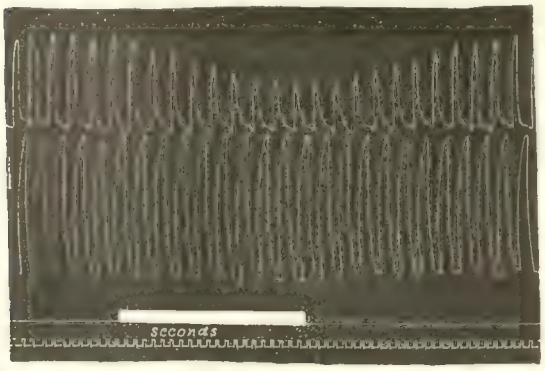

FIG. 3406.—Stimulation of the *Left* Vagus. Weak stimulus. Same specimen as in Fig. 3405.

1882. Eckhard[34] showed that the excitability of the heart is decreased during vagal inhibition (Schiff had pointed this out in 1850). Gaskell and Heidenhain brought out the importance of separating the inhibitory and accelerator fibers in order to obtain pure inhibition. This was accomplished in the frog by intracranial stimulation (which was virtually the method used by the Webers).

After Gaskell[56] had well studied the frog he turned his attention to the land tortoise (*Testudo greca*) and several types of reptiles. He reached two very important conclusions: (1) The primary action of the vagus upon the heart of cold-blooded animals is a direct one upon the muscle fibers; it affects all of their properties in the same way, diminishing *rhythmicity, excitability, conductivity, contraction force,* and *tonicity.* (2) The cold-blooded vertebrates are divisible into two sets, those of the amphibian type, in which the ventricle is affected in the same way as the auricle, but to a less degree, and those like the Teleostei, Chelonia, and Reptilia, in which the inhibition seems confined to the auricles. In this connection Gaskell brought out his theory that the vagus is the anabolic nerve of the heart. The theory will be considered later, as will be also the question of the direct action of the vagus.

These early conclusions of Gaskell were supported by the work of Wesley Mills[111(a)] on the heart of the terrapin, toad fish, and Menobranchus, and by experiments of MacWilliam[100] on the frog, toad, newt, and several mammals. From this time on work along comparative lines was extended, with important results. These will be taken up in the next section.

After 1890 studies on cardiac inhibition were multiplied rapidly. Bayliss and Starling[4] worked upon the weakening effect of the vagus, showing that it is especially prominent in the auricles. Johansson and Tigerstedt[144] emphasized the importance of the strength of the stimulus used. Hough,[70] in this country, pointed out that the length of time the heart could be inhibited varied in different animals, and in different individuals of the same species. He described experiments showing (1) that vagus escape could not be due to fatigue of the vagus but to changes in the heart muscle, and (2) that the efficiency of vagus inhibition varied inversely as the vigor of the heart. Knoll[87] found that the vagus effect extended to the central ends of the large veins emptying into the heart, and that sometimes the ventricles beat at the same rhythm as the great veins, while the auricles were quiescent. Engelmann,[41] impressed with the conflicting results of various workers, and the consequent complexity of the subject, made in 1896 the most complete analysis of cardiac regulation up to that time, and his results are in good agreement with those of most modern methods. He conceived that each nerve, vagus and accelerator, could affect the heart's four properties—rhythmicity, contractility, irritability, and conductivity. An influence that intensified or increased any one of these properties he called *positive* and any influence having the opposite effect he called *negative.* Thus the vagus was negatively *chronotropic* (retarding), negatively *inotropic* (weakening), negatively *bathmotropic* (lessening irritability), and negatively *dromotropic* (diminishing conductivity). The accelerator had an opposite action. Engelmann believed that these negative effects were mediated by different fibers of the vagus, in the frog, a view that was opposed by others but which has received support recently. The decision of the question was made possible, as we shall see, by the help of the Einthoven galvanometer, the invention of which marks a distinct epoch in the physiological and clinical study of the heart.

The historical development of inhibition has not been confined to the heart, however. In 1841 A. W. Volkmann[149] saw that destruction of the medulla,

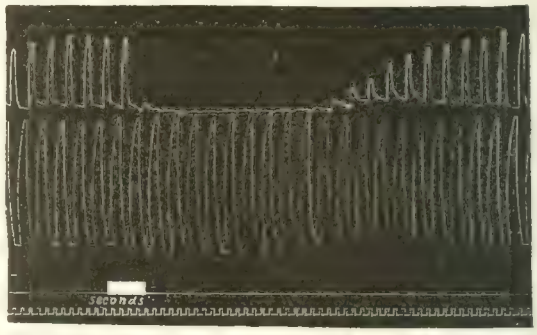

FIG. 3407.—Stimulation of the *Left* Vagus. Stimulus and specimen same as in Fig. 3405. Auricles only inhibited

or section of the vagi, caused increased peristaltic movement of the stomach.* As already mentioned, Pflüger discovered in 1855 that stimulation of the splanchnic nerve caused inhibition of intestinal peristalsis. In 1858 came Bernard's discovery of vasodilator nerves in the chorda tympani. Rosenthal in 1862 pointed out that the superior laryngeal nerve when stimulated caused inhibition of inspiration; thus he first experimentally demonstrated inhibition of striated muscles, the seat of the inhibition in this case being later proved to be in the central nervous system. In 1864 Goltz showed that mechanical stimulation of the abdominal viscera or blood heart caused diastolic standstill of the four lymph hearts in the frog. The year previous he published his well-known observation on the reflex inhibition of the blood heart in the frog by a blow upon the abdomen—the "klopfversuch." He proved that it was reflex inhibition as it did not occur if the vagi were severed.

* For specific references not given in the remainder of this section see Meltzer's paper [107(3)]

In 1866 came the important discovery of Ludwig and Cyon[94] of the depressor nerve, which, it is now generally believed, produces reflex vasodilatation of the peripheral splanchnic vessels by lowering the tonus of the vasoconstrictor center in the medulla. In 1868 Hering and Breuer published their equally important discovery of the regulating action of the vagus nerve on the respiratory center. They showed that distention of the lungs inhibited inspiration and excited expiration. Other examples of reflex inhibition rapidly accumulated from the work of Goltz, Schlösser, Lewisson, Goltz and Freusberg, and others, frogs being the animals mainly used.

In 1878 Vulpian claimed that there were inhibitory nerves in the cervical sympathetic supply to the sweat glands of the horse. Kronecker and Meltzer established the fact in 1881 that in the rabbit each deglutition inhibits the tonicity of the cardiac portion of the stomach, and in 1883 they showed that marked inhibition of the esophageal peristalsis follows each deglutition. At this time Meltzer added the interesting observation that the inhibition attending each swallowing act extends to various centers, diminishing the tonus of the cardio-inhibitory, vasomotor, and respiratory centers, and even spreads to centers in the lower part of the spinal cord. It could also inhibit reflexes started by peripheral stimuli. These observations appear to be the first proof that inhibition is an integral constituent of a normal function.

Oser in 1884 obtained opening of the contracted pylorus by stimulating the splanchnic. He also reported that this stimulation abolished peristalsis of the stomach. In regard to the intestine, there was a growing impression that the vagus contained inhibitory fibers for it also. The circular fibers of the vagina and uterus were found by Fellner, in 1887, to have inhibitory nerves which reached them by way of the nervi erigentes. The year 1887 marks another noteworthy observation. Biedermann[9] found that in the cray-fish (Astacus) stimulation of the distal end of the nerve supplying the claw muscles produced relaxation of the closing muscles and at the same time contraction of the opening muscle. As the nerve fibers go directly to the muscles, it was an instance of peripheral inhibition of striated muscles; and at the same time it was an interesting example of coordinated action of antagonistic muscles. It should be stated that Richet[127] made this same observation in 1882.

The discussions about the vagus during all these years had often developed into long controversies. One of these was in regard to the nature of the effect on respiration produced by stimulation of the central end of the divided vagus. There were many who were not convinced that the stopping of respiration caused by such an experiment was really true inhibition. In 1892 Meltzer[107(a)] proved that it was. By division of the spinal cord, thus paralyzing the expiratory muscles, he showed that stimulation of the central end of the vagus produced real inhibition of inspiration, as it caused relaxation of the inspiratory muscles.

Evidence was supplied at this time by Contejean, Wertheimer, Morat, and others showing that the vagus also contained inhibitory fibers for the stomach and intestine. In 1894 Camus and Gley found fibers in the splanchnic which inhibited the receptaculum chyli. The most brilliant work was being done by Sherrington[133] who brought out the remarkable fact that the cortical area for inhibition of a group of muscles coincides with the area for the contraction of the antagonists of that group. Thus, to quote him, if the third and fourth cranial nerves on one side, *e.g.* the left, are severed, so that the rectus externus remains the only unparalyzed ocular muscle, appropriate excitation of the cortex cerebri produces conjugate movements of both eyes toward the opposite side, *i.e.* from left to right. The movement of the left eye can only be due to inhibited tonus of its external rectus by the cortical excitation. This experiment was confirmed by Topolanski in 1898. Another example of central inhibition was furnished by Pal in 1898. He reported that stimulation of the spinal cord below the centers of the splanchnics inhibited intestinal peristalsis. To allude again to the vagus, Pawlow,[115] in 1896-98, discovered that this nerve contained inhibitory as well as secretory fibers for the pancreas. Doyon in 1897 found vagus inhibitory fibers for the bronchial muscles.

The next most noteworthy contributions date from the opening years of the present century. They have to do particularly with cardioinhibition and inhibition in the central nervous system owing mainly to the improved technique of Einthoven and Sherrington in the two respective fields. It will be convenient, therefore, to end our chronological citations at this point.

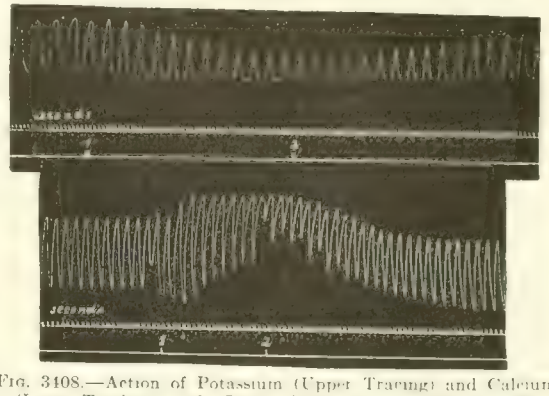

Fig. 3408.—Action of Potassium (Upper Tracing) and Calcium (Lower Tracing) on the Perfused Frog Heart. (Simpson[140])

Comparative Physiology.—*Subchordates.*—An account of the comparative physiology of inhibition to be comprehensive must begin with the lowest organisms, for there can be no doubt that phenomena analogous to the familiar inhibitory processes in the highest forms can be observed in those lowest in the scale, or at least in the protozoa. If we conceive inhibition to be a temporary retardation of life processes, this is certainly true. Organisms can be easily put into such a state by various means. In general, the different stimuli or agents that excite organisms will also inhibit their activities under certain conditions.* Such inhibition, as far as the external manifestations of life are concerned, cannot be held to be fundamentally different from inhibition as we ordinarily conceive it in higher forms.

A few examples of inhibition in invertebrates may be cited. Pütter[126] has shown that if freely swimming Paramecia are subjected to a temperature of 30° C. they move about rapidly in all directions, while those in contact with slime particles remain attached. Only when the temperature is raised to 37° do the attached specimens release their contact and swim violently through the water. The experiment shows the interference between a thermal and contact stimulus. Jennings[75] has also studied extensively interference reactions of the lower organisms.

One may also recall the effect of the constant current upon *Amœba proteus*, and *Paramecium aurelia*. In the former, the whole animal becomes elongated and at the cathode there is developed distinct evidence of depression, while at the anode the protoplasm shows excitation. In *Paramecium aurelia*, the cilia on closing the circuit, relax at the cathode and at the

*For discussion of this matter, see Verworn's "Allgemeine Physiologie," 1909, or Lee's translations of the earlier editions, and "Irritability," Verworn Silliman Memorial Lectures, Yale University, 1913).

anode they go into a contracted condition. It is well to mention at this point that Biedermann[10] and others showed that the constant current produces a polar effect in all kinds of muscle, namely, a relaxation at the anode and contraction at the cathode, on closing the circuit. Nerve, as is well known, shows in a beautiful way this condition of anelectrotonus and catelectrotonus. Whether or not these polar effects in the unicellular organisms and the highly specialized tissue, as muscle and nerve, are of the same nature cannot be said, but in all likelihood they are. Other examples of depression might be given for the protozoa, but these will suffice. Plants show evidence of excitation and depression just as certainly as animals do, but we have not space to enter into that subject (see Bose [13]). In what follows we shall deal only with specific mechanisms of inhibition as found in the vascular system of animals, which will be taken up in the linear order of Parker and Haswell.

Inhibition has been most fruitfully studied in the vascular system of animals, especially in connection with the heart. Cardiac inhibition is found low in the animal scale and has been pretty well studied, though much remains to be done by newer methods.

The writer has found no date earlier than 1867 recording definite observations of inhibition in invertebrates.* In that year Paul Bert[7] found that stimulation of the visceral nerves in the cephalopod, Sepia, caused inhibition of the systemic heart. Since then it has been shown by Carlson that cardio-inhibition probably exists below the molluscs. In echinoderms the vascular system shows evidence of rhythmic activity of its muscular fibers, but no specific regulatory nerves are known to exist. In the worms we doubtless meet with such fibers first. Carlson reports that in Arenicola stimulation of the ventral nerve cord with a weak interrupted current usually inhibits the esophageal hearts in diastole. In Neries he got evidence of inhibition of the dorsal vessel. He does not consider that the experiments proved the presence of inhibition, as there was no way of knowing how much contraction of structures adjacent to the hearts influenced their rhythm. Nevertheless, he writes:[19] "Here (in the worm phylum) at the very threshold of the heart rhythm, speaking phylogenetically, we are confronted with essentially the same fundamental conditions as in the heart of the highest vertebrate. There are the same tissues, viz., muscle, ganglion cells, and nerve plexus; and apparently the same type of regulatory nerves: motor and inhibitory." Further experiments are necessary to settle the question of inhibitory and excitatory nerves in the worms, as the early work was often faulty. However, we have the experiments of Stübel[141] who obtained diastolic standstill of the pulsating part (heart) of the vascular system of the earthworm by stimulating with strong currents in the neighborhood of the clitellum. He found nerve tissue in the animal, and his results in general are in accord with those of Carlson in Arenicola and Neries. Stübel inclines to the view that in Lumbricus there is reflex control of the peristaltic contractions of the vessels.

Arthropoda.—Cardioinhibitory nerves have been demonstrated in the highest crustacea, as in the crayfish (Palinurus, Carlson), in the crab (Conant and Clark), and in the lobster. Carlson is quite confident he has seen them in the insects, *e.g.* the polyphemus moth, grasshopper (*Dictyphorus reticulatus*) and the tarantula (genus and species unknown). In Limulus, an arachnid (commonly called the horseshoe crab), there can be no doubt about cardiac inhibition. Limulus deserves particular mention because its thorough study by Carlson lead him to some very important conclusions regarding the origin of the heart beat and its control. In this animal the anatomical arrangement of the heart's nerve supply, while of a primitive type, is such that the augmentor and inhibitory fibers can be separated with certainty. The nerves run superficially the entire length of the elongated heart as a ganglionated cord in the dorsomedian line; the inhibitory fibers arise from the brain and the augmentor ones from the abdominal chain of ganglia. Carlson has shown that this nerve cord on the heart is essential for the automatic contractions, since on removal of the cord the beats cease. He further showed (*a*) that the inhibitory fibers acted upon this cord and not upon the heart directly, and (*b*) that the inhibitory effects were essentially like those in the vertebrate heart. Hoffmann[69] has confirmed Carlson in regard to the action of the inhibitory nerves upon the ganglion of the heart and not upon the heart directly. From these facts Carlson argued that the burden of the proof in the dispute over the nature of cardiac inhibition, as to whether it is direct or indirect, falls upon those who, like Gaskell and others, hold that it is direct. While the truth of Carlson's results in Limulus cannot be questioned, it is not safe to say that they apply in their entirety to the mammalian heart as well, because the two types of heart muscle differ in fundamental properties. In discussing this group, it may be added that inhibition of blood-vessels in arthropods doubtless exists, but has not been demonstrated.

Tunicata.—There seems to be no definite evidence of inhibitory nerves in this group. Nerve cells and fibers have been found in *Molgula manhattensis* by Hunter, but direct proof of the nature of their action is lacking.

Mollusca.—Cardioinhibitory fibers make their first appearance in the gastropods, according to Carlson. He was able to obtain both inhibitory and augmentor effects, and to record them graphically by stimulating the visceral nerve in Triopha, a representative of the suborder of nudibranchs. In the lower order of prosobranchs, of the gastropods, and in the giant Cryptochiton, representing the amphineura, he obtained only augmentor effects on the heart. In the land snail, Helix, and the slug, Ariolimax and Limax, all from the pulmonates, cardioinhibitory fibers exist, while in the tectibranchs, Aplysia and Bulla, and in the pleurobranchs they have not been found, probably because of the predominance of augmentor fibers. In the lamellibranchs and cephalopods Carlson, Bert, Ransom, Botazzi, and others have shown cardioinhibitory fibers. Carlson found the cephalopods have only inhibitory nerves, or at least these greatly predominate. This fact of the presence of augmentor nerves only in the lowest molluscs and of inhibitory nerves mainly in the highest suggests, he thinks, that the augmentors antedate the inhibitory in time of development. An important general conclusion reached by him was that in the molluscs the inhibitory effects upon the heart are identical with those in the vertebrates, namely, partial or complete arrest in diastole, diminished amplitude of beat, and usually fall in tonus. It may be stated also that, in cephalopods at least, vasoinhibitory effects could be shown.

Chordates.—Inasmuch as inhibitory nerves have been shown to appear definitely in the invertebrates, their presence in the lowest chordates was to be expected. It must be admitted that there are some gaps to be filled in. Thus, in Balanoglossus, Cephalodiscus, and Rhabdopleura, marine forms of doubtful classification, nothing is known of inhibitory nerves, so far as the writer is aware, and in the more advanced animal, Amphioxus, the same is true.

Vertebrates.—Among the cyclostomes one finds two closely related animals with a striking difference in heart physiology. Greene[59] discovered that the systemic heart of the California hagfish (*Bdellostoma dombeyi*) is not provided with cardioinhibitory nerves, and neither is the portal heart of the animal. The observation was confirmed by Carlson,[21] who found, on the other hand, that the fresh water lamprey

* See Carlson[20] for literature to 1909.

(Ichthymyzon) possesses both augmentor and inhibitory nerves for the heart. Whether or not the marine lampreys have such nerves is an interesting point which seems not to have been determined. In these cyclostomes no observations have been recorded on vasomotor or dilator nerves.

Fishes.—The Webers long ago found cardioinhibitory nerves in the vagus of fishes, as others since have done. Greene[60] observed vagal inhibition of the heart in eleven species of bony fishes and one shark. Kolff[81] has recently made an extensive study of the vagus nerve in several Teleosts—*Telestes muticellus, Barbus fluviatilis, Anguilla vulgaris.* In several instances he got vagal inhibition of the heart (in Telestes). He found vagus tonus by dividing the vagi. He also observed reflex inhibition of the heart and coordination of the heart and respiration. He reviewed the literature, especially the work of Botazzi, Bethe, Schönlein, Cadiat, and Thesen, who obtained cardiac inhibition in Torpedo, Scyllium, Squala, and various other bony fishes. The work of MacWilliam[101, 102] on eels is to be mentioned also. The Dipnoans appear not to have been studied with reference to inhibition.

Amphibians.—These have been extensively studied. The frog has served in many experiments which have given us important facts about the regulation of the heart beat particularly. The Webers used it in their first experiments on the vagus. The amphibia seem, without exception, to have cardioinhibitory and augmentor nerves, and vasomotor nerves. The lymph hearts are also provided with both motor and inhibitory nerves (Eckhard[35]). In the frog we have definite quantitative and qualitative differences between the two vagi in their action on the heart. A hint of this possibility was earlier found by MacWilliam[102] in the eel.

Reptiles.—Of the different members of this numerous group the Chelonia have been most extensively studied. The early work of Gaskell on the tortoise has been referred to, and it is not necessary to go further into these historical details. They form a most important factor in the development of cardiac physiology and have paved the way for more exact knowledge of the phenomena of inhibition in general.

Birds.—Vagal inhibition of the heart in birds was first observed by R. Wagner,[151] in 1854. Four years later Claude Bernard announced that he never was able to produce complete arrest of the bird heart by stimulation of the vagus, and various other observers have come to conflicting conclusions about the subject. In 1909 Jürgens[77] reviewed the literature on vagal control of the avian heart and described experiments on twenty-eight pigeons. He recorded the contractions of the auricle and ventricle, and by stimulating the peripheral end of the vagus obtained inhibition varying from slight slowing to complete standstill of the whole heart for as long as 3.4 seconds. The action of the vagus extended to the ventricle in some instances, so he states. Contractility was diminished; seldom was it increased. Results on the conduction and irritability of the heart were negative. Division of the vagi was without effect, indicating no tonus of the inhibitory center.

In 1910 Stübel[142] made more extensive studies of the circulation in birds. He worked with fourteen different kinds and was led to conclude that the effect of the vagus on the heart varies in different birds. The effect on the rate was most striking in the domestic duck. In birds of prey it was variable. In the domestic hen complete arrest of the heart was possible. He also brought out the fact that in several different birds the right vagus was more active than the left; and he found further that stimulation of the central end of the vagus caused reflex slowing through the other vagus. Double vagotomy in a few cases (*Milvus milvus*) produced increased rate of beat and rise of blood pressure. Paton[116] has recently described some observations upon the duck's heart. He confirmed Jurgens' statement that the vagus center is not in constant action in the duck. In some of his specimens he could maintain complete arrest of the heart for several moments, and he found that not only the auricles but also the ventricles were influenced.

One other example of inhibition in birds may be given. Fredericq[47] in 1893 called attention to the interesting fact that in diving birds an especially long expiratory pause may be produced by allowing a stream of water to flow over the beak. Miss F. M. Huxley[73] has lately studied this reflex apnea in the duck with interesting results. She found that submergence of the entire head is required. It causes immediate cessation of respiration, in whatever phase it may be. Dorsiflexion of the duck's head produces reflex inhibition of the breathing, even out of the water, if the vertex of the head faces downward. Dr. Paton[117] has extended these experiments on the duck and has shown that several articulations take part in this postural inhibition. They are the occipitoatloid joint, the midcervical joints, and the cervicodorsal articulations. He studied the part played by the labyrinths also, and states that in all cases the labyrinths dominate and control the cervical mechanism. There is great variation in the extent of this control, however. An interesting fact is that in this postural apnea there is slowing of the heart. The bird is therefore longer able to resist asphyxia, because the demand for oxygen is reduced by the decreased metabolism in the heart.

Cardiac Inhibition.—We may now consider the more recent contributions to inhibition of the heart. It has been shown by earlier work that when one vagus nerve is cut in the neck of an animal there is an increase in heart rate, and when both vagi are severed the increase is still greater. When such results are obtained they show that the vagus center possesses marked tonicity. If the peripheral end of one vagus is stimulated the heart beat is slowed, or stopped altogether. Quantitatively, the result will depend upon the strength of stimulus, and, in some animals, upon which vagus is stimulated. If inhibition is complete the heart stops in diastole, being fully dilated and distended with blood. The whole heart is in a state of complete relaxation. Furthermore, it has been shown by a number of ex-

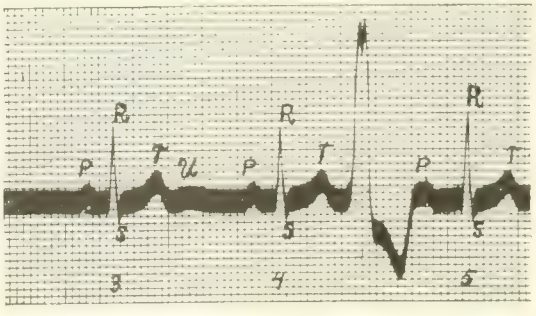

Fig. 3409.—Normal and Atypical Electrocardiogram from a Human Subject. The "*U*" wave results from the auricular beat; the "*RST*" group from the ventricular beat. A ventricular extrasystole occurs between normal beats 4 and 5. 1 mm. on the abscissæ = 0.04 second. 1 mm. on the ordinates = 0.1 millivolt. (Dresbach and Mumford[30].)

perimenters that there is also depression of conductivity and doubtless of irritability. During excitation of the vagus the heart may begin to beat ("vagus escape") and may regain its former rhythm. The escape from vagus action is not seen equally well in all animals, however, and, indeed, the chronotropic effect is quite variable in the same species. Harrington[63] has shown that it is quite likely dependent upon the nutritive condition of the animal, and recent experiments have brought out more clearly the dif-

ference in action of the two vagi. It was early noted that excitation of the right vagus often had a more pronounced negative chronotropic action than stimulation of the left vagus. This was frequently observed in the turtle, for example. In mammals the chronotropic fibers are frequently present in both vagi.

The introduction of the Einthoven [36] galvanometer has made possible a closer analysis of the vagus and its distribution in the heart. This instrument, the moving system of which consists of a very slender conducting fiber suspended between the poles of a powerful electromagnet, is exceedingly sensitive and rapid in its deflections. It gives an accurate record of the action currents of the heart. The movements of the galvanometer "string" caused by these action currents can be photographed, and the record, known as the "electrocardiogram," can be studied with reference to disturbances of heart rate, rhythm, conduction, sequence of events in the different chambers, and force of beat to some extent. Thanks to Prof. Einthoven's epoch-making advance in the technique of cardiography, physiological and clinical studies of the heart have been greatly enriched (Fig. 3409).

In 1906 Einthoven,[37] in his paper, "Le Telecardiogram," showed that vagus stimulation produced heart-block as well as the ordinary effects upon the number of beats. In 1908[38] he pointed out that the loss of vagus tonus caused by severing the two nerves affects particularly the auricles and conduction system. The "P" wave (representing auricular contraction) was increased, and the conduction time shortened slightly. The ventricular systole was also slightly shortened. Stimulation of the peripheral end of one vagus decreased the auricular systole and strong stimuli abolished it. The conduction time was lengthened and the ventricular systole slightly prolonged. The effect on the ventricle was ascribed by Einthoven to other causes than vagus inhibition. After cessation of the stimulus the auricular beat gradually increased in strength, while the ventricular contraction was maximal at once. There was temporary complete heart-block during recovery from the vagal effect. From these experiments he concluded that stimulation of the vagus produced depression of the auricles and conduction system, as well as decreased rate of impulse formation.

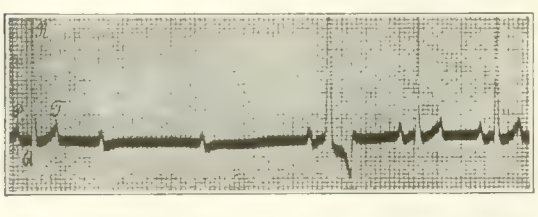

FIG. 3410.—Morphine Heart-block. Central vagus stimulation. Two "*P*" waves (auricular beats), not followed by ventricular beats, appear. An atypical beat of the ventricle follows the fourth "*P*" wave. (Einthoven and Wieringa.[39])

Further work by Einthoven and Wieringa [39] in 1912 substantiated this conclusion. Morphine, which stimulates the vagus center, was used on dogs under chloroform anesthesia. It was shown that central stimulation of the vagus by morphine may produce the same result as stimulation of the peripheral vagus by electricity. By varying the dose of morphine different degrees of dissociation between auricles and ventricles could be produced, and it was shown that the depression could affect either the right or the left division of the A-V bundle. Atypical ventricular systoles were produced, and complete heart-block could be obtained. That the effect was entirely central was proved by paralyzing the vagus center with an overdose of morphine, by cutting the vagi, and by paralyzing their terminations with atropine. After each of these procedures the heart beat became normal, except in rate, which was increased of course. As the authors state, the simplest explanation of the results is that the vagus contains fibers distributed to various parts of the heart—one set to the auricles, one to the A-V node (Tawara) and another to the A-V bundle and its two branches. These different fibers are stimulated unequally by small doses of morphine, producing the effects described, which are in agreement with the results of Kahn[78] and Somojloff[121] who, among others, have studied electrocardiographically the effects of vagus stimulation.

Almost simultaneously with the paper by Einthoven and Wieringa came one by Eyster and Meek and another by Cohn, the galvanometer method being employed. Eyster and Meek[46] studied the effects of morphine stimulation of the vagus in dogs. They conclude that the central stimulation by morphine depresses most the conduction between the pace maker of the heart and the auricle (sinoauricular block) and to a less degree the conduction from auricle to ventricle; and they state that after atropine the recovery of the conductivity occurs sooner in the sinoauricular system than in the auriculoventricular, as a rule, and that apparently the former is the first to be affected by the morphine. During recovery from the morphine they also saw various degrees of sinoauricular and auriculoventricular block. There was some depression of contractility of the auricles and slight lengthening of the ventricular systoles during the vagus stimulation. Their curves do not show atypical ventricular beats and they do not mention the possibility of depression of the right or left branch of the A-V bundle or its main stem alone. The distribution of the vagus in the heart is not discussed. In a recent paper[46(b)] these authors have shown that stimulation of the vagus may cause a shifting of the pacemaker of the heart.

Cohn,[24] who comes to the same general conclusions as Einthoven, paid particular attention to the differences between the two vagi. He used dogs and stimulated the nerves by the faradic current. He went further in his conclusions than the above writers. He was able to show that in the dog there are fundamental differences in the action of the two vagi in eighty-eight per cent. of the cases (fifty-four experiments were made). His results are summarized as follows:

"1. Stimulation of the right vagus nerve in the dog usually causes arrest of all chambers of the heart.

2. Stimulation of the left vagus exerts a moderately negative chronotropic effect on the auricles.

3. Stimulation of the left vagus has a profound effect on the conduction of impulses over the auriculoventricular system. The degree of this effect varies, causing delay in transmission, incomplete, and in some dogs, complete heart-block.

4. Stimulation of either vagus may cause ectopic ventricular systoles.

5. Stimulation of the left vagus may rarely cause sinoauricular block; possibly stimulation of the right vagus may also produce this effect."

Stimulation of the vagi in human beings has been recently repeated, the effects on the heart being recorded by the string galvanometer. Robinson and Draper[129] have done it on several adults and four children, the individuals having hearts usually showing inflammatory lesions and irregularity of rhythm. In hearts showing auricular fibrillation, stimulation of the right vagus caused, as a rule, marked slowing of the ventricular rhythm without producing any appreciable effect on the fibrillations of the auricle. The slowing of the ventricles was apparently due to blocking of impulses from the auricles. In some cases a definite difference was demonstrated between the action of the two vagi. The control of the rate of beat seemed to predominate usually in the right vagus, while the control of stimulus conduction from auricles

to ventricles predominated usually in the left vagus. In general, the results of vagus stimulation in these cases correspond remarkably with those in the dog. It is well known that some danger attends such experiments, but Robinson and Draper state that no fatal results have been reported. They saw no sign of danger in their own cases. The human heart seems to escape readily from vagal inhibition. Cohn[25] states that vagus pressure should be tried in all cases of paroxysmal tachycardia, and the attempt should not be confined to one vagus alone, for in case of failure success might follow compression of the opposite vagus. The danger in this procedure seems to be very slight. It is discussed by the authors cited and literature on the subject is given. It has been proved by Cohn, Hoffmann, Wenckebach, Bensen, and others that in paroxysmal tachycardia vagus compression may control the paroxysm and for that reason its employment seems justified, but in view of the small number of cases reported this treatment should be used with caution. An important paper by Ritchie[128(b)] reviews the whole subject of the stimulation of the human vagus.

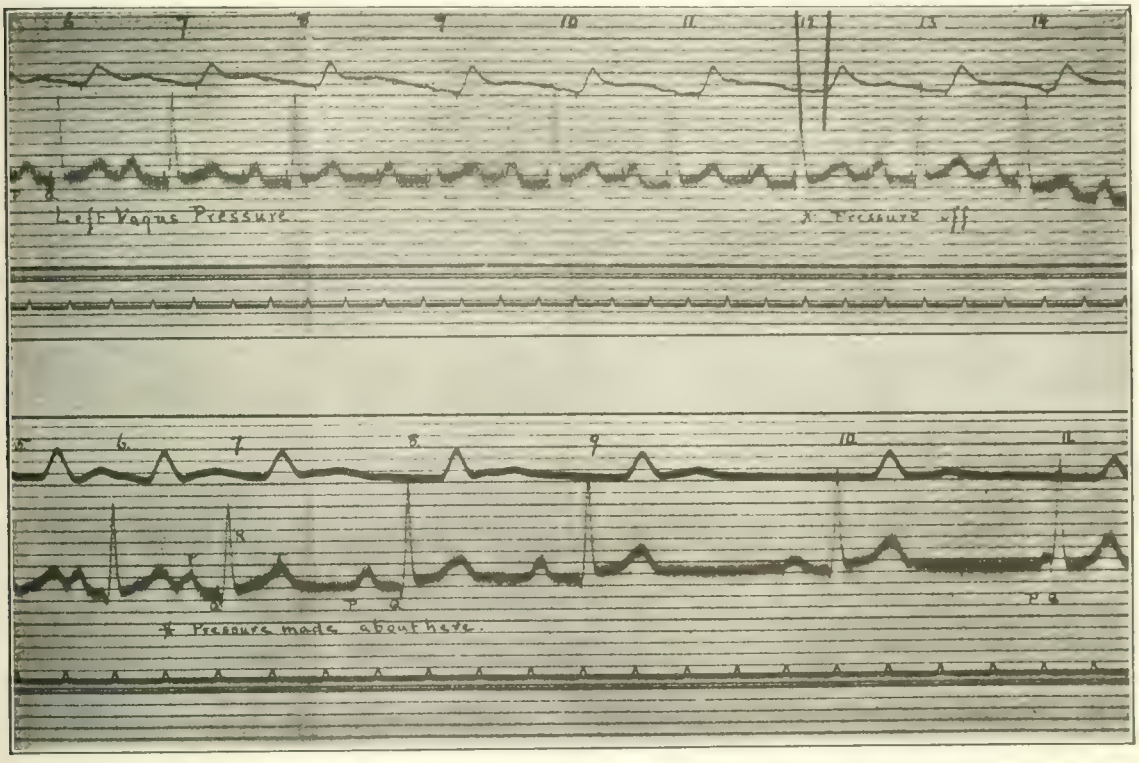

Fig. 3411.—Stimulation of the Human Vagus by Compression in the Neck. Electrocardiogram and brachial pulse. Left vagus (upper tracing) shows no effect. Time marked in $\frac{1}{5}$ second. (Robinson and Draper.[129])

As to the question of direct action of the vagus upon the ventricles there has been a long discussion. Gaskell concluded long ago that, in the terrapin at least, the vagus affects only the auricles. Bayliss and Starling[4] stated, on insufficient grounds, that the ventricles in mammals are directly influenced by this nerve. H. E. Hering,[66] working on cats, dogs, rabbits and apes, also believed in the action of the vagus on the ventricles, but the basis for his belief has since been shown to have been inadequate (Erlanger and Hirschfelder[43]). Rihl,[128] working in Hering's laboratory, supported the latter's claim as to the ventricular effects of the vagus. In the experiments of Hering and Rihl, the attempt was made to isolate, in various ways, the auricles from the ventricles, and then to observe the effect of vagus stimulation. Using the rate of beat alone as the criterion the results of Hering and Rihl are convincing, but Erlanger and Hirschfelder showed in 1905 that the probability of the vagus inhibiting the ventricles directly is slight. However, Frédericq[56] has demonstrated upon dogs a finding previously reported by Garrey in this country, namely, that it is possible to clamp the muscle tissue without injuring the inhibitory nerves. By this means Frédericq claims to have shown distinct effects of the vagus upon the dog's ventricle. But in all such experiments in which artificial physiological discontinuity is established between portions of the heart there is risk of inception of abnormal conditions which lead to doubtful conclusions. The experiments of Lewis[87] offer more convincing evidence of direct action of the vagus upon the ventricles. Lewis produced paroxysmal tachycardia in dogs by ligating the coronary arteries. There resulted a heterogenetic rhythm of the ventricles. Vagus stimulation slowed these paroxysmal contractions, arising in the ventricle, in thirty per cent. of the dogs used.

Garrey[54] has attempted to analyze the conditions responsible for the conflicting views. Using the turtle (Pseudemys), he found that in functional heart-block stimulation of the vagus may produce results of exactly opposite character, and he has shown that the rate of beat under these experimental conditions is not a safe criterion on which to base conclusions as to the terminations of the vagus in the ventricles. The actual effect of vagus stimulation is the resultant of several factors, such as position of the clamp causing the block, the strength of stimulus used, the involvement of accelerator fibers, and amount of chronotropic change.

From his records Einthoven sees no certain evidence of direct action of the vagus upon the ventricles, but Angyan,[1] working in the laboratory of Thos. Lewis, has added striking evidence bearing upon this point.

He used cats, etherizing them and then producing dissociation of the auricles and ventricles by partial asphyxia. When the auricles in one case were quite still and the ventricles were beating, stimulation of the right vagus caused complete standstill of the independently beating ventricles. The experiment seems to be crucial as, in Fig. 3412, the abolition of the auricular beat has not rendered the ventricular contraction especially abnormal. The point of action of the vagus cannot be stated definitely.

It is evident that, as far as existing methods can show, the action of cardiac nerves upon the ventricles is not yet sufficiently elucidated. It is not surprising that the cardiac nerves appear to have but little direct effect upon this part of the heart, as nerve tissue in the ventricles is difficult to demonstrate. However,

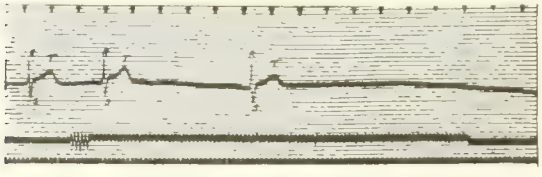

Fig. 3412.—Slowing of Independently Beating Ventricle by Right Vagus Stimulation. (Angyan.)

Waledinsky[152] has succeeded in showing pretty clearly that in the mammalian ventricle nerve tissue is present. Whether or not the vagus affects the intrinsic ganglia as Carlson[22] contends, and not the heart muscle directly, as Gaskell, Bayliss and Starling, and others have maintained, remains to be settled. In any event the inhibition depends upon specialized terminations of the vagus, for Erlanger[44] has shown that if the vagus is cut and to its peripheral end the central end of an ordinary spinal nerve (as the fifth cervical) is sutured, and time allowed for regeneration to take place, stimulation of the spinal nerve will now cause inhibition of the heart. Further study with the Einthoven galvanometer upon hearts under normal conditions will doubtless be of great value in this important field. Langley's[86] experiment on the chorda tympani and cervical sympathetic are also pertinent. Additional important recent contributions on cardiac vagal influence have been made by Cohn and Lewis (*Journal Exp. Med.*, 1913, xviii., 715, 739), Lewis (*Heart*, 1914, v., 247), and Eyster and Meek.[46(b)]

Reflex inhibition of the heart in mammals is a common laboratory and clinical phenomenon. One may often obtain it by stimulation of the central end of one vagus, the other being intact. There are many other nerves which can be caused to produce reflex cardiac inhibition in animals. Such experiments form the basis for the belief that in man the afferent fibers in the vagus conduct the impulses which produce reflex slowing of the heart in the bradycardia associated with sudden distention of the stomach, acute inflammatory states of the alimentary tract, peritonitis, etc. In addition, the inhibitory center can be stimulated by impulses from the higher brain centers, by pressure on the medulla, and by changes in the composition of the blood such as in asphyxia (Mathison[103]), it is believed. It is to be remembered that impulses arriving at this center from any source may not necessarily cause inhibition of the heart. Certain stimuli may depress the inhibitory center, and thus accelerate the heart beat. Furthermore, the close relation of the cardio-inhibitory to other centers in the medulla, such as the respiratory, vasomotor, and the cells giving rise to the accelerator fibers, makes the result variable. It should be stated that the so-called cardio-inhibitory center has not been delimited anatomically, but it is believed that the cells from which the cardio-inhibitory fibers arise are in the region of the origin of the vagus nerve.

The tonicity of the vagus inhibitory cells is maintained largely by incoming impulses, especially those arriving by way of afferent fibers in the vagus trunk itself. Of these fibers those that constitute the depressor nerve are of paramount interest because of the part they play in the reflex adjustments of the heart beat and blood pressure. Marey (1859) is credited with being the first to observe the slowing of the heart that takes place when there is rise of arterial pressure. Since Marey's discovery numerous observations along this line have been made. The literature will be found reviewed by Eyster and Hooker[45] who have experimentally shown that the slowing of the heart that occurs from rise of blood pressure is due to two factors—direct effect of increased pressure upon the cardioinhibitory center, and reflex stimulation of the center by afferent nerves. The afferent path has its origin, at least to a great extent, in the thoracic aorta, as was shown by Köster and Tschermak in 1902, both on anatomical and physiological grounds. They found that distention of the aorta produced action currents in the depressor nerve, and they suggested that normally impulses reach the cardioinhibitory center by this route as a result of increased pressure in the aorta acting as a stimulus to the depressor nerve fibers. Einthoven[40] has recently studied the action currents in the vagus, and he finds that they are initiated by the inspiratory and expiratory movements of the lungs and by the heart beats. When the depressor nerve was separated from the vagus fibers proper, it was found that the action currents due to the systoles of the heart were confined to the depressor, while the action currents due to lung movements were absent from the depressor nerve fibers but present in the main trunk of the vagus. Hence it appears that the sudden increase in the aortic pressure consequent to each heart beat acts as a stimulus to the depressor nerve. Einthoven therefore holds the same view as Köster and Tschermak that these stimuli in the depressor help to maintain the vagus tonus and he further suggests that they may also reach the respiratory center and contribute to the automatic adjustment of the rate of the respiratory movements along with the pulse frequency. One may also think of the possibility of the afferent impulses ascending the vagus fibers from the lungs affecting the cardiac centers in turn, and thus the whole question of the coordination of these centers takes on added interest in the light of these studies.

*Drugs and the Cardioinhibitory Mechanism.**—The action of various drugs upon the cardio-inhibitory apparatus will not be discussed in detail. We have a number of drugs which are important in this connection. Some of them act centrally upon the vagus, such as digitalis, aconitine, picrotoxin, veratrine, cocaine, caffeine, morphine, when given in proper doses; others, like muscarine and pilocarpine, stimulate the peripheral vagus in the heart, pilocarpine acting upon the vagus ganglion connections and muscarine upon the end organs; nicotine first stimulates and later paralyzes the intrinsic vagus ganglia; atropine is valuable because it paralyzes the vagus terminations in the heart, as does also apocodeine. With some of these drugs, the slowing of the pulse rate is due in part to the rise in blood pressure produced by the stronger heart beat. This fact suggests that it is well to remember the direct action such drugs have upon the heart, especially the digitalis series, adrenalin, aconitine, and spartein.

Clinical Aspects of Vagal Inhibition of the Heart.—There are several conditions in which vagal influence on the heart is met with clinically. In connection with heart-block, certain types of arrhythmia, auricular fibrillation, and the action of the digitalis bodies,

* For fuller discussion of this subject, see: Sollmann's "Text-book of Pharmacology," 1906; Cushny's "Pharmacology "and Therapeutics," Meyer and Gottlieb's "Pharmacology" (translated by Halsey, 1913).

chloroform, adrenalin, and a number of other drugs we have to do with vagal effects.*

The Vagus and Heart-block.—In the discussion in the preceding section it has been shown that the vagus can depress the auriculoventricular conduction system, and it might be inferred that some cases of auriculo ventricular block are due to such depression. There is no good evidence that defective conduction can result in this way to the extent that it becomes a real disturbance. It is known, however, that inhibitory influences may increase the grade of a pre-existing defect in the conduction system (Lewis[88] and Mackenzie[98]).

Respiratory Arrhythmias of the Heart.—These may be physiological or pathological. The former are seen in youthful subjects and are due to variations in the tonicity of the cardioinhibitory center during respiration, probably because of overflow of impulses from the respiratory center. During convalescence from fevers and some other conditions these fluctuations in pulse rate accompanying respiration have been seen. With digitalis, fluctuations in the heart rate have been noted. Very slow pulse and periodic standstill of the heart of pathological origin have been recorded by Mackenzie, Laslett, Wenckebach, Edes, and others.[88] Some of the causes are known to be pressure of tumors upon the vagus, fractures of the cervical vertebræ, and contractions of the foramen magnum. While vagal inhibition is known to produce slowing of the heart in an irregular manner in clinical cases, it is a great mistake to ascribe irregularities indiscriminately to this cause, and it is likewise a great error to assume that tachycardia in a given instance is due to loss of vagus tonus. Galvanometric records of various types of increased heart rate have shown the frequency of much graver causes, especially auricular fibrillation.

The Vagus, Auricular Fibrillation, and the Action of Digitalis.—It has been established that the vagus inhibits impulse conduction in the heart; it is known that auricular fibrillation is the condition in which digitalis has its most characteristic effect (Lewis[88]); this effect may be in part due to the action of digitalis upon the conduction system by vagus stimulation. These points may now be conveniently discussed together.

The present status of the question as to how digitalis retards the ventricles when the auricles are fibrillating can best be indicated by reporting the recent views of prominent workers studying the problem. In these cases of fibrillation the digitalis bodies slow the ventricles by enhancing a previously existing auriculoventricular block. The electrocardiogram demonstrates this, but one cannot be so certain as to the exact point of action of the drug. Mackenzie,[99] in his extensive study of digitalis, found that in patients whose pulse rate was being kept reduced by this drug atropine would immediately cause a marked rise in the pulse. In some cases it was nearly doubled; the inference was that digitalis had been maintaining the slow rate by stimulating the vagus. This view is supported by the fact that compression of the vagus will often produce the same result, as already stated. On the other hand, Cushny, Marris, and Silberberg[26] have detailed the results of digitalis action in two types of cases—nonfibrillating and fibrillating. They state that in the former class the members of the digitalis group slow the pulse in a certain number of instances in which the rhythm is given by the normal pacemaker, and as a general rule this slowing may be removed by atropine and is therefore inhibitory. In other cases, however, the sinus slowing and block are unchanged by atropine, and hence the action of the digitalis is direct upon the conduction fibers from pacemaker to auricle and from auricle to ventricle. Their study of auricular fibrillation indicated that the percentage increase in the pulse rate caused by atropine after treatment with digitalis was less than the increase following atropine without digitalis. They were therefore lead to the curious result that the slow pulse produced by digitalis in their cases of auricular fibrillation was not only not due to vagal stimulation but that there was an actual decrease in the inhibitory influence in many cases. They therefore concluded that the reduction in ventricular rate was due to a direct depression of the conduction fibers, or of the excitability of the heart muscle by the digitalis.

We cannot go into a discussion of the probable explanation of these discordant results obtained by Mackenzie and Cushny. The cases were of the same general type and were treated in the same general way. It would appear that the reaction to digitalis is a matter of individual differences in different patients. There is need of more extended studies by means of the electrocardiogram, using more accurate doses of digitalis as prescribed by Hatcher[61] in his studies of the digitalis series. The writer, in some observations on the action of ouabain on the cat's heart, studied by the Einthoven galvanometer, has been impressed by certain peculiar effects of the ouabain upon the conduction system before there was any marked change in the pulse rate. The studies are not completed and it is not possible yet to analyze them, but it was evident that there were some obscure effects of this drug worthy of extended study.

The subject of fibrillation of the cardiac muscle is also in need of further investigation. The theory as to its cause which has gained most prominence lately is that championed by Lewis and others who maintain that the fibrillation is due to the generation of impulses simultaneously at several foci. They believe that altered irritability is the prime disturbing factor, and the belief is well supported by electrocardiographic studies of experimental and clinical cases. Garrey[55] supports the theory of "blocked conduction." By ingenious experiments upon the turtle and mammalian heart he shows that the mass of the heart muscle is an important factor in fibrillation. He induced this condition in various parts of the heart and then isolated portions of different sizes by clamping or excision. Small isolated masses ceased fibrillating while the remaining part of the heart (auricle or ventricle) kept up the delirium. Garrey established the important fact that if the point at which fibrillation is started is excised the fibrillation continued in the remainder of the auricles or ventricles excited by the original stimulus. This speaks against the theory of simultaneously acting foci of new impulses. Garrey states that the persistence of cardiac fibrillation is, other conditions being equal, directly proportional to the size of the tissue mass involved. Long, narrow, thin pieces recover promptly, and narrow strips connected to a fibrillating mass do not fibrillate, even when they are stimulated by the faradic current. They beat coordinately. The experiments support the block hypothesis originated by Porter[124] in 1894. He held that the contraction waves were prevented from running their course by depressed conductivity in various parts of the heart muscle. As Garrey conceives it, the impulses can spread in any and all directions from the initial point of irritation, their progress being limited only by the localized areas of depressed conduction. These areas divert the impulses into more circuitous paths and the areas so blocked off can participate in contraction only where stimulated by an impulse from another direction. These areas then become the centers from which impulses travel, only to meet with blocks at other points.

Lewis, Erlanger, Hirschfelder, and others have also observed the blocking of impulses in fibrillating heart muscle by narrow or thin strips; nevertheless, we have these two different conceptions as to the nature of the fibrillation process, one ascribing it to the development of foci initiating new impulses, the other to localized areas of blocked conduction. In view of

*See Lewis, "The Mechanism of the Heart Beat," 1911, for more extended discussion of these subjects.

the strong evidence that both the production of new foci of impulse formation and the presence of depressed conduction are possible causes of fibrillation, it does not seem wise to ascribe the condition to either factor alone.

Fibrillation, Section of the Vagi, the Action of Chloroform and Adrenalin.—We may mention finally an important experimental observation on the possible relation fibrillation has to chloroform anesthesia and adrenalin action. Levy,[91] in a paper on the exciting causes of ventricular fibrillation in animals, has shown that in cats under chloroform anesthesia section of both vagi will very frequently set the ventricles to fibrillating. Section of the vagi has no clinical analogue, but it is quite possible that the vagal tone can be depressed and in such a condition *light* chloroform anesthesia might predispose the ventricle to fibrillation. Levy and Lewis[92] have shown, too, that intravenous injections of adrenalin during light chloroform anesthesia will produce ventricular fibrillation and death. The fibrillation is ascribed to the stimulation of the accelerator mechanism of the heart at a time when the muscle is hyperexcitable from the chloroform. These results indicate that great precaution should be used in the administration of adrenalin in man during the action of this anesthetic. Several fatalities have occurred (Levy[91]).

Vascular Inhibition.—As in the heart, we have in the blood-vessels of most organs, and in plain muscle fibers generally, a double nerve supply. In the blood-vessels these are known as the pressor and depressor nerves. The problems of inhibition in the blood-vessels are at bottom, the same as in vagal control of the heart.

The vasodilator nerves are widely distributed in the body. The heart, lungs, and brain have not been proved, beyond question, to contain either constrictor or dilator fibers, however (Howell[71]). Where they do exist, vasodilator nerves when stimulated inhibit the tone of the circular fibers. Unlike the constrictor nerves, they are not in constant (tonic) activity; and they do not arise from any one center in the cord. Experimental evidence shows that there are several levels in the cord at which the dilator nerves have origin.

The depressors seem to be excited reflexly (see Fig. 3414), but their centers, like those of other nerves, are doubtless influenced by changes in the composition of the blood. In order that they may act, there must be a certain degree of vasoconstriction. Examples of reflex vasodilatation are the erection of the penis, congestion of the salivary glands, and perhaps the dilatation of the skeletal muscle vessels during contraction. The dilator fibers doubtless exert a direct influence upon the blood-vessels, but reflex vasodilatation may also be brought about by inhibition of the tonus of the vasoconstrictor center in the medulla. This is, in fact, what happens when the depressor nerve of the heart is stimulated. This nerve has already been discussed in connection with the vagus and we need only to emphasize again the importance of this reflex mechanism of the vascular system, governing, as it does, the splanchnic vessels especially.

Most study of the vasomotor nerves has been directed to the arteries, but it is known that the veins have a nerve supply. Lymph vessels have received less attention in this respect. The presence of dilator nerves in the receptaculum chyli has already been mentioned in the historical outline.

The degree of contraction of the blood-vessels is not controlled alone by the nerves. The products of metabolism, such as carbon dioxide and lactic acid, are believed to cause relaxation to some extent. The opposite effects are produced by the secretion of the adrenal glands and infundibular portion of the pituitary gland. It is known, however, that the adrenal secretion acts upon the constrictor nerve endings in the blood-vessels. The distending force exerted by the heart and propagated therefrom is another factor influencing the tonicity of the blood-vessel wall.

Inhibition in the Alimentary Canal.—Inhibition in the digestive tract has been known since Pflüger's discovery in 1855 of splanchnic inhibition of the small intestine. Motor fibers for the stomach and small intestine predominate in the vagus supply; inhibitory fibers occur mainly in the splanchnic. The large intestine is supplied by the sacral and lumbar outflow (Howell[71]).

It will not be possible to review all of the extensive work which has been done upon inhibition in the alimentary canal. Numerous researches have established the fact of an inhibitory mechanism for all parts of the tract. The subject is well discussed by Cannon[15] in his book, "The Mechanical Factors of Digestion," 1911. The valuable *x*-ray studies by Cannon have shown how closely the different parts of the digestive canal are correlated and how susceptible they are to influences operating through the extrinsic nerves. The acid control of the tonicity of the cardiac and pyloric sphincters is one of the most interesting examples of adaptations of nervous mechanisms that we have. Peristalsis is also doubtless carried out by a local reflex arrangement which produces a constriction of the canal preceded by an inhibition of the circular fibers in front of the advancing contents. These delicate adjustments of constrictor and dilator nerves of the canal are easily disturbed by various conditions, such as emotional states, pain, exposure of the viscera, etc. From such studies the pathology, as well as the physiology, of the digestive system now stands in a clearer light. In this connection should be mentioned the important studies by Carlson and his associates on the nervous control of hunger contractions (*Am. Jour. Physiology*, 1914–15).

Inhibition of the Respiratory System.—The movements of respiration may be inhibited by the stimulation of several different nerves. It is known that during inspiration certain fibers of the vagus are stimulated by the expansion of the lungs and the result is that inspiration is brought to a close. Deflation of the lungs, under experimental conditions, excites a different set of vagus fibers. These facts have been demonstrated most clearly by Einthoven[40] who showed that both inflation and deflation of the lungs give rise to action currents in the vagus. The presumption is that normally one set of vagus fibers is excited by the expansion of the lungs with the result that inspiration is inhibited at a certain point, while diminution in volume of the lungs excites another set of fibers and thus brings expiration to a close. It is quite generally agreed that inspiration is inhibited in the manner described, but it is not yet certain that in ordinary quiet respiration the expiratory phase is ended by nervous activity. The importance of the vagus control is shown by the profound effect section of the two vagi has upon the character of the movements. Their rate is much decreased and the depth increased, because of the loss of the stimulus which normally stops inspiration.

The inspiratory part of the respiratory center may be inhibited by stimulating the superior laryngeal nerve and in some animals by stimulation of the nasal branches of the trigeminus. Inhibition of breathing by stimulation of the nose in diving birds has already been discussed, and likewise the interruption of breathing by the act of swallowing. Many cutaneous nerves also inhibit respiratory activity. Volitional control of the center need scarcely be mentioned.

The bronchial muscles have long been a subject of investigation as to their function. They are now

known to have inhibitory fibers (Doyon[31]) as well as constrictor nerves. (Dixon and Brodie[29].)

Inhibition of Striated Muscle.—After the discovery of inhibitory nerves for cardiac and plain muscle the search for such nerve supply to striated muscle went on. The first instance was published by Pawlow[111] in 1885. He found inhibitory nerves running to the adductor muscles of the bivalve mollusc Anadon. In 1887 Biedermann[11] discovered inhibitory nerves for the claw muscles of the arthropod —Astacus. Piotrowski[121] in 1893 reinvestigated the nerve supply to the muscles in the crayfish and concluded that the inhibition takes place in the muscle and not in the motor nerve endings.

In the vertebrates inhibition of the skeletal muscles takes place centrally, *i.e.* in the motor nerve cells, by the effects of afferent nerves acting upon these cells. It has been claimed by several, nevertheless, that inhibitory nerves run directly to the striated muscle of vertebrates. Wedensky[154] made this claim in 1885, as did also Kaiser[79] in 1892. (The Wedensky phenomenon —the apparent inhibition of striated muscle by the stimulation of its motor nerve—has caused much discussion among physiologists. For a recent critical study of it see the important paper by Keith Lucas, *Journ. of Physiol.*, 1911, xliii., 46.) It is known with certainty that inhibition of the motor nerve cells of the muscles does occur. As Sherrington says, skeletal muscle has become so wholly dependant upon the central nervous system that it contracts only when the immediate spinal or cranial centers summon it to do so. With a muscle so stimulated to action a simple plan to inhibit the muscle is to inhibit its motor center. It is not surprising, then, to find that such a plan is carried out in the vertebrate body. Sherrington[134] takes very little stock in the idea that inhibition of skeletal muscle takes place any other way. The subject of reflex inhibition and inhibition of reflexes as developed by him and others will be outlined in a subsequent section.

Inhibition in Nerve Fiber.—Studies of inhibition in nerve fiber have been greatly overshadowed by the study of the phenomenon in muscle tissue. Excepting the numerous investigations of the phenomena of electrotonus in nerve, and some other conditions which increase and decrease the excitability and conductivity of this tissue, very little has been done on the inhibitory state in nerve fiber as a special problem. It is, in fact, not a special problem here, except in so far as conductivity and excitability, rather than contractility, are the functions inhibited.

Under the influence of the galvanic current the well-known changes in irritability and conductivity in nerve described by Pflüger[120(a)] take place. When a constant current, not too strong, is passed through a nerve, there is increased irritability and conductivity around the cathode (catelectrotonus) and decreased irritability and conductivity (anelectrotonus) around the anode. On breaking the circuit the conditions are reversed as regards the two poles, the anode becoming the seat of rise and the cathode the seat of fall in excitability. Few experiments in physiology have stood the test of time so well as these of Pflüger, and, though his conclusions have been extended the original results remain practically unaltered. The results of numerous researches on these electrotonic changes show that they probably occur in all tissue capable of being stimulated by the galvanic current. The depression of the properties of nerve fiber around the anode under the action of the galvanic current has not received a completely satisfactory explanation, but for the present purpose we may speak of it under the general subject of inhibition.

Inhibition and Secretion.—Inhibitory nerves have been alleged for several different glands but the difficulty of excluding the possible action of vasomotor nerves, which would alter the blood supply to the gland under observation, has rendered doubtful many of the conclusions drawn. Pawlow[115], Popielski, and v. Anrep[116] (1911) claimed to have found inhibitory nerves in the vagus supply to the pancreas, and Morat attributed inhibitory effects to the splanchnic supply to the pancreas. Various writers have mentioned the inhibitory fibers of the gastric glands. Arloing[2] seems to have demonstrated such fibers for the lacrymal and sweat glands in the cow and donkey. It is claimed by Pawlow (Howell) that the prolonged secretion of saliva which follows section of the chorda tympani (paralytic secretion), is due to the loss of inhibitory influences. It cannot be said, however, that the various glands of the body have been proved to have inhibitory nerves acting either directly upon the gland cells or indirectly upon ganglion cells which might have connection with them as, for example, in the salivary glands. It appears that the latter are controlled by a center in the medulla (Miller). This, however, may be nothing else than the nuclei of origin of the secretory nerves which leave the medulla by the facial and glossopharyngeal nerves. Inhibition of the salivary secretion may consist of an action upon this center and thus be analogous to the inhibition of striated muscle. As evidence supporting the possibility of direct inhibition, it is stated that when the cervical sympathetic is stimulated there is a positive electrical variation in the submaxillary gland. This is taken to mean depression of the cells, as a negative variation occurs when the gland secretes.

In connection with secretion may be given the control of the gall-bladder. According to Doyon,[32] the splanchnic contains fibers which inhibit the contraction of the gall-bladder and bile duct and at the same time cause contraction of the sphincter in the duodenal papilla. The vagus causes the opposite effects upon these structures. If this mechanism really exists, and there is little reason to doubt it, it is a beautiful example of antagonistic muscular action.

Another phase of the subject is the possible action of internal secretions as inhibiting agents. There is some evidence along this line. Schäfer and Herring[132] found that extracts of the posterior lobe of the pituitary gland when injected into the circulation caused a dilatation of the renal blood-vessels and secretion of urine. The extract contained a depressor substance acting specifically upon the renal vessels. They believed, also, that the hypophysis contains a second substance which inhibits the renal epithelium.

According to Jordan and Eyster,[76] extracts of the pineal gland contain a depressor substance which produces dilatation of intestinal vessels and fall in blood pressure, but results are rather uncertain in the hands of various experimenters with extracts of this gland. Diminished activity of the gland in children appears to accelerate the development of the generative organs, inducing precocity and increased growth of bones (Pellizzi[118]).

In the theories of sugar metabolism inhibition takes some part. Thus, Zuelzer[156] believes that the output of sugar from the liver is controlled by two opposing hormones, an accelerating one, epinephrin, from the adrenal glands, and an inhibiting one from the pancreas. The basis of his belief is briefly this: If the pancreas is completely removed from an animal, hyperglycemia and glycosuria result. Ligation of the adrenal veins prevents these results of depancreatization, it is claimed by Zuelzer. Then there is the work of Eppinger, Falta, and Rudinger[42] which is also credited with supporting the idea of antagonism between the pancreas and the chromaffin system. It must be said that experimental evidence is not yet satisfactory on this point, and the whole subject of sugar metabolism is in too unsatisfactory a state to warrant further discussion of possible inhibitory phenomena in this field.

We may allude finally to one other interesting fact, namely, the increased vagus tonus which characterizes

the complex condition known as "status thymicus," or "status thymolymphaticus." It has been thought that some internal secretion, possibly of the hyperplastic thymus, could be the cause of the high vagus tonus and resulting slow heart rate in these cases. Biedl[12] states, however, that this tonus is more probably due to diminished activity of the adrenals.

Inhibition in the Central Nervous System.—In the historical introduction to this paper it was pointed out that Charles Bell in 1823 first spoke definitely of the necessity of inhibitory nerves antagonizing the excitatory nerves. In spite of the notable discoveries of reflex inhibition by Ludwig and Cyon,

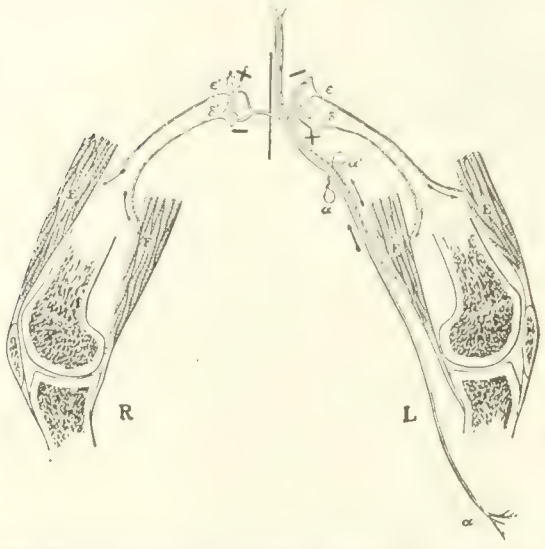

Fig. 3413.—Schema of Reciprocal Innervation. *E*, extensor, *F*, flexor muscles of knee, α and α', afferent neurons. The + and − signs indicate points of excitation and inhibition, respectively, of the central motor neurones. (Sherrington,[134(b)] Yale Press.)

Hering and Breuer, Goltz, and others already mentioned, it was not until sixty years after the suggestion of Bell that the subject of central nervous system inhibitory phenomena began to receive systematic study. In 1881 Kronecker and Meltzer[82] discovered that, in the rabbit at least, during deglutition there is normally an inhibition of the tonus of the cardia, the effect being mediated by the vagus fibers supplying the stomach, for the inhibition did not take place if the vagi were cut. In 1883 Meltzer[105] called attention to the purposeful arrangement of the respiratory mechanism, in which the superior laryngeal, trigeminus and splanchnics may cause inhibition of inspiration. Already in 1883 Meltzer advocated such nervous system reactions as types of a general principle and in 1903[106] he called it the principle of "contrary innervation." In 1906 Sherrington brought out his book, "The Integrative Action of the Nervous System." In this extensive analysis of the nervous system functions Sherrington studied the reflex arc as the unit of reaction. Prior to his work the physiological problems of the nervous system had been attacked mainly from two directions. Under the influence of the doctrines of the cell theory certain investigators were especially interested in the nerve cell as a unit. The problems of the nutrition of neurones and their relations to other cells received emphasis. Verworn and his co-workers contributed valuable studies in this field. Then, the special feature of nerve tissue—its power to conduct impulses—was also being intensely studied by numerous investigators, and there resulted a great fund of information about the specific properties of nerve and its reactions to stimuli. In this field we have Helmholtz, Pflüger, Biedermann, Du Bois Reymond, Bernstein, and a host of others. Sherrington set out to investigate more especially a third aspect of nervous reactions, namely, their "integration," that is, "the welding together of the higher reactions which constitute the behavior of animals as units in the natural economy." This coordination of animal processes is carried on in three ways. First, there is mechanical union of cells into a single mass by means of intercellular bridges, connective-tissue coverings and frameworks, as in glands, muscles, etc.; secondly, we have chemical coordination, by hormones and other bodies, circulated from one organ to another by the blood and lymph; thirdly, the nervous system, as a very special agent, serves to bring about harmonious action in the animal organism. The third method of integration is phylogenetically much later in origin than the other two. It is characterized by quickness of reaction, which is accomplished by physicochemical disturbances conducted along highly specialized lines of cells (neurones) by which distant organs are rapidly brought into connection with each other and with their environment. The problem, then, was to analyze the nervous coordination, and the motor reactions were studied with this end in view. The results accomplished by Sherrington and many others have reached a vast extent, and it will be possible to do no more than outline them with special reference to the inhibitory phenomena.*

It is necessary to state here some fundamental conceptions in regard to reflexes. Reflexes are the reactions of animals (1) to external agents, or stimuli; and (2) to internal stimuli. In those forms having a nervous system there are special tissues which carry out the reactions. The conception of a reflex mechanism is that it embraces at least three separate structures: (1) an initiating organ, or receptor, in which the reaction starts, (2) a conducting nervous path, (3) the *effector* organ, *e.g.* a muscle, which completes or carries out the reaction. We have to deal, then, with three processes, *initiation*, *conduction*, and *end effect*. The end effect may be a contraction of any kind of muscle, secretory activity of a gland, or a state of consciousness. In the latter instance the reaction is not called a reflex, however; it nevertheless consists of initiation, conduction, and end effect.

The receptor organs which are acted upon by the environment make up the *exteroreceptor* field. When receptors are so situated that they respond to changes arising in the organism (internal stimuli), as in muscle, tendon, joints, etc., they are called *proprioceptors*. In many reflexes both classes of receptors are in action. The reflexes are for the most part very complicated. A motor mechanism moving an extremity may be started to action by a number of stimuli coming from widely separated regions. The resulting impulses must converge to a "final common path," to use Sherrington's expression, in order to act harmoniously. Reflex arcs thus acting are called "allied" arcs. These may have as their end result excitation or inhibition, and in order that movement may occur there must be simultaneous excitation of one set of muscles and inhibition of their antagonists. The innervation of antagonistic muscles, such as flexors and extensors, which provides for their harmonious action can be understood from the schema (Fig. 3413). The mechanism of the reciprocal relation thus established is in principle a simple one. The inhibition of skeletal muscle is always reflex. In the words of Sherrington,[135] "the motor center is a convergence point for various reflex influences competing, so to speak, for dominance over the muscle. The motor center lies as an instrument passive in the hands of opposing

* The reader is referred to Sherrington's book and to his recent excellent summary[135] of the work on reflex inhibition by himself and others. (See also T. Graham Brown, Quart. Journ. Exp. Physiol., ii.-vii.)

forces of excitation and inhibition, exerted by nerve channels which infringe upon it. Sometimes the one influence and sometimes the other prevails."

Reciprocal innervation operates not only in the skeletal muscle system. The same principle applies in the heart and blood-vessels in the antagonistic action of the two sets of nerves in these structures; it is to be found in the alimentary canal and elsewhere in the production of the peristaltic movement, which consists of a wave of relaxation going in advance of a wave of contraction; the coordinated action of the constrictor and dilator fibers of the iris illustrates it; in short, wherever antagonistic muscles act we have provided an arrangement for producing simultaneous excitation and inhibition. Reciprocal innervation does not always mean reflex action in the sense of spinal reflexes. The mechanism may be a local one, as in the Auerbach plexus of the intestine. In the case of the arthropod claw muscles it is again peripheral and simpler still apparently.

To return to the muscles of the higher animals, it has been shown that the principle enunciated holds in the assumption and maintenance of posture just as well as in the production of movement. The tonus thus maintained in skeletal muscle has its analogue in the tonus of the artery muscle in so far as the latter is governed reflexly. Bayliss[3] has investigated the question as to whether an impulse causing a reflex fall in arterial pressure does so by inhibiting the tonus of the vasoconstrictor centers or by increasing the tonus of the dilator centers, or by a combination of both of these. He shows that the last possibility is what actually occurs. In the general vasomotor reflexes, therefore, the centripetal impulses act reciprocally on the nerve centers of antagonistic influence. When arterial pressure is raised the initiating impulse excites the constrictor center and inhibits the dilator; when the reflex produces a fall in pressure the dilator centers are excited and the constrictor inhibited. It is also stated that local as well as general vasomotor adjustments exhibit reciprocal innervation.

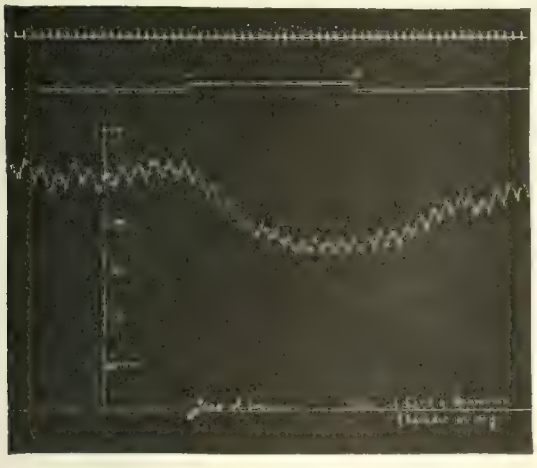

FIG. 3414.—Reflex Fall in Blood Pressure by Stimulation of the Depressor Nerve, in the Rabbit. (Dawson, in Howell's Textbook of Physiology, 1913, W. B. Saunders Co.)

Sherrington and his pupils have brought out many important facts concerning the phenomena of reflex inhibition. Their studies reveal that not only does inhibition serve to suppress reflexes but it also acts as a delicate adjuster of the intensity of reflex contraction. This it does by grading the intensity of the nerve-center's centrifugal discharge. This provides for the nicest adaptation of the contraction to the needs to be met. And the same is true in the grading of postural tonus and in rhythmic reflexes, such as stepping. Thus nature works economically. In connection with these rhythmical movements Sherrington[156] has recently shown in a very interesting and striking way that by taking an afferent nerve that produces steady reflex excitation of a muscle, and another which produces steady reflex inhibition of the muscle, it is possible by stimulating both nerves concurrently to obtain regular rhythmic contractions and relaxations of each member of a pair of symmetrical muscles, the phases being reciprocal in the two. The experiment shows that under the rivalry of two opposed and equipoised continuous stimulations the limbs exhibit reflex walking. With certain other paired intensities of stimulation only one limb will step, while the other will be kept steadily flexed. Here we have a beautiful demonstration of the result of opposing influences in the nervous system in the production of rhythmic movements. It is interesting to follow Sherrington further as he shows that nervous inhibition seems in many ways the exact opposite and counterpart of excitation. He points out that nervous excitation is certainly rhythmic, Piper[122] having shown that its natural rhythm in mammalian neurones is about fifty impulses per second. The question arises, then, as to whether or not inhibition is likewise rhythmic. The discharge of fifty impulses per second from nerve centers is equivalent to continuous stimulation in comparison to the slow periods of such muscular acts as breathing and stepping, for example. The problem is to find out how these rapid nervous discharges are converted into the much slower periodic motion of muscle. Several hypotheses have been advanced. Thus, Graham Brown[14(c)] suggests tentatively that the rhythmic phenomenon is a matter of balanced activities of spinal cord centers of opposite character, one set controlling excitation and the other inhibition of muscles. The stimuli from the muscles are of great importance, he thinks, and fatigue of the centers is a conditioning factor in the rhythm. Doubtless the chemical state of the blood is also to be reckoned with. Forbes[49] also suggests that perhaps

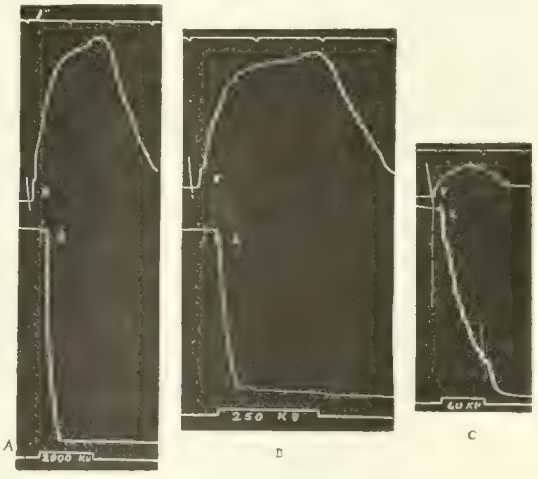

FIG. 3415.—Reciprocal Reflex of Flexor Muscle, *F*, and Extensor, *E*, of the Knee, Excited by Stimulation of the Afferent End of the ipselateral popliteal nerve. Three strengths of stimulus used. (Sherrington [156])

all of these oscillations are manifestations of a general tendency of opposed influences in reflex centers, although themselves continuous, to produce rhythmic activity. He thinks that the rhythm may be conditioned by intensity of stimulation or by time relations. Sherrington is apparently not ready to state his views as to the exact nature of these opposed processes in the nerve centers, though he has worked

out many of the controlling conditions. He considers various explanations and suggests a possible anatomical arrangement which may be the basis for the reciprocal action following a centripetal impulse. Uexküll and Groos[145] have found that the peripheral nerve path, stimulation of which causes contraction of the adductor and relaxation of its antagonist in the arthropod claw, splits near its distal end into an excitatory division to one muscle and an inhibitory branch to the other. Sherrington conceives that this same arrangement may exist in the cord centers, a centripetal fiber splitting into two terminals, one excitatory and one inhibitory.[136] These two branches, it is believed, infringe on one and the same final common path or center, the result being rhythmic action, as experiments show. Verworn[147(b)] presumes on physiological grounds that this splitting into two of such fibers takes place in the intermediary neurone of the reflex arc. Sherrington favors the view that in rhythmic movements (reflex stepping) "two reflex influences—one excitatory and one inhibitory—are concurrently at work in closely balanced intensity; that in the presence of these the intrinsic processes of 'fatigue' and 'successive induction' (exalted activity following inhibitions) occurring in the nerve centers produce an alternate predominance of momentum of the reflex inhibitory mechanism and its process. It has also been shown that reflex inhibition, like excitation, tends to persist after the cessation of the stimulus, from which fact the inference is drawn by Sherrington that the poststimulatory persistence of a reflex action is due not only to momentum in the motor neurones and the final common paths of the nerve centers, but also to a concomitant persistence of the inhibitory influence.

Further, we may have fatigue of reflex inhibition as well as of reflex excitation. From the work of Forbes[49] it appears that this fatigue does not involve the reflex center as a whole. It appears to be limited to the particular paths of approach to the center. Camis[17] has shown that maximal stimulation of one afferent nerve does not evoke all the reflex excitation of which the center is possible, and it would seem that in the case of inhibition a similar statement can be made.

An additional fact of great interest and significance is that certain reflexes can be reversed, so that a reflex ordinarily resulting in excitation becomes inhibitory, and *vice versa*. A number of such instances have been found by Magnus and Uexküll, Graham Brown, Bayliss, and Sherrington.[135] Bayliss has noted, for instance, that at a certain stage of chloroform narcosis an excitatory effect in the vasomotor system is changed

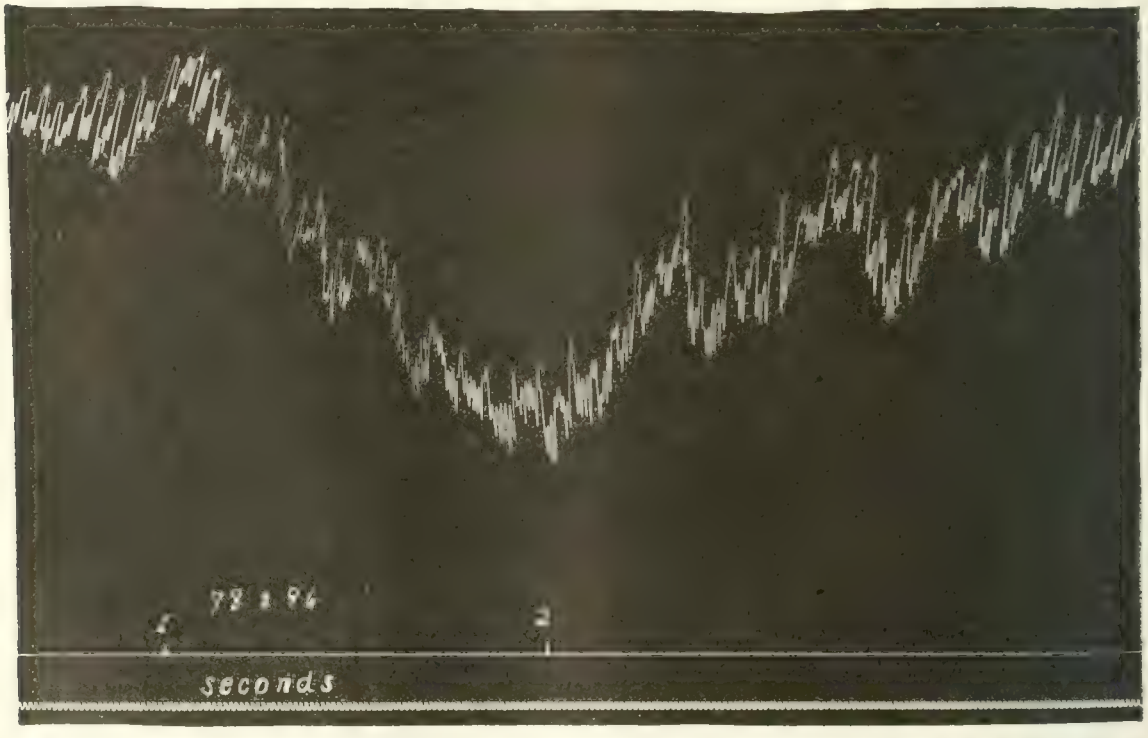

FIG. 3416.—Plethysmographic Record of Volume Change in Forearm, a pressor effect in the vasoconstrictor center as the result of doing a mental problem (78 × 96). An inhibition of dilator centers probably occurs at the same time. (Record by A. E. Livingston.)

effect of the one and then of the other of the two opposed extrinsic influences." Verworn has endeavored to simplify the whole matter of the interference of stimuli. His theory we shall consider later.

Mention must be made of certain other characteristics of the inhibitory processes in nerve centers. As studies of the subject have proceeded, the closeness of the correlation of inhibition with excitation has become more and more apparent. Thus, in the transition from one reflex act to another, reflex inhibition corrects the inertia of the excitatory mechanism and the momentum of the excitatory process, and *vice versa*, reflex excitation counteracts the inertia and into an inhibitory one, and Sherrington has observed that strychnine and tetanus toxin may, in properly graded doses, change an inhibitory effect into an excitatory. A state can be reached in which the reflex relaxation is diminished but is not replaced by excitation. In this connection Sherrington[133] writes: "This phenomenon shows well how little competent is the view of lowered spinal resistance really to explain the action of strychnine; for at this stage the stimulated arc that normally acts on the extensor muscle by inhibition is less able to affect it than before, so that on the spinal resistance view the resistance at this stage is actually heightened" (see Pike[120(b)]).

Allusion should be made to one other matter before we close this section, namely, to the subject of spinal shock. It has long been known that injury to the cord, *e.g.* section below the medulla, is followed by a period of depression of its functions. The severity and duration of the depression vary in different animals. On the whole, the monkey exhibits "spinal shock" best among laboratory animals. Various explanations of the condition have been offered. Goltz is mainly responsible for the idea that it is a state of prolonged inhibition in the cord. Believers in the presence of automatic centers in the cord have taken refuge behind this hypothesis. Thus, Brown-Séquard held that the cause of the cessation of respiration when the cord is severed just below the medulla is that the assumed spinal respiratory centers are thrown into a state of inhibition by the section. Porter[125] has conclusively disproved this explanation of the cessation of respiration, and has shown that the phrenic motor cells are still able to discharge impulses, though not rhythmically. The theory of prolonged inhibition does not hold in this conspicuous instance. It has very little to support it and very few physiologists adhere to it.

No mention has been made thus far of the influence the higher centers have on the reactions taking place in the spinal cord. While it is no longer supposed that there are certain centers which have an exclusive function of inhibition, it is known that certain parts of the brain exercise restraint over the spinal centers. After removal of the cerebrum there results marked rigidity of muscles, especially of the head, neck, and fore limbs. The condition is known as "decerebrate rigidity" (see Sherrington for description). The decerebrate animal has been much used in the study of inhibition, partly because of the ease with which certain spinal reflexes can be elicited and partly because anesthesia can be dispensed with. Furthermore, artificial respiration is not necessary, as a rule. The decapitated animal is also much employed.

The analysis of inhibition in the complex processes of the cerebrum has not proceeded so far as in the case of the spinal functions, but much has been accomplished. There is no longer any doubt that the principle of reciprocal innervation obtains in the highly organized systems of neurones which form the basis of mental systems. Here we enter the field of sensation, volition, and attention, etc. Much work has been done in recent years on the rôle inhibition plays in these processes. Reciprocal innervation thus becomes of great significance to the psychologist and psychotherapist. (For literature on these subjects see the papers by Heymanns,[67] MacDougal,[97] Breese,[14(b)] and Jacobson,[74] and text-books on psychology, such as those by Wundt,[155] Ladd and Woodworth,[84] and Münsterberg.[112])

Theories of the Nature of Inhibition.—As a matter of historic interest it may be noted that Volkmann's[150] "interference" theory is about the earliest attempt to explain inhibition. He proposed that in the nervous system there could be an interference of waves of nervous action, somewhat similar to interference of waves of light or of sound. The suggestion, occasionally repeated, has no experimental basis. Wundt[155] in 1880 asserted that inhibition is caused by certain stimuli rendering latent the energy set free by destructive changes. This theory also has no support. Years before this (1858) Schiff had maintained that inhibition is a manifestation of fatigue. Twenty-five years later he abandoned the view.

Inhibition has been said to be due to fatigue, to resistance to nerve impulses (Mercier[109]), to interference of stimuli, etc., but the theory that has gained widest favor is the trophic or metabolic theory advanced by several contemporary physiologists, Hering,[65] Gaskell,[57] Verworn,[146] Meltzer, and others. These writers emphasize the assimilative phase of metabolism. They hold that inhibition is essentially a preponderance of the anabolic over the catabolic changes. Hering's view became known especially through his "theory of color vision." Gaskell's writings were based upon his studies of the heart. He believed that the vagus inhibits the heart by checking the catabolic processes. This is accomplished, he thought, by increasing the anabolic processes. His belief rested mainly on two sorts of evidence, first, that the heart after a period of vagal inhibition beats more vigorously (showing a rebound similar to that of reflex inhibition in the nervous system), and secondly, that during vagal inhibition the heart shows an electrical variation of opposite character to that when it contracts (positive instead of negative variation). Now, it has never been proved that these results are due to an increase in the assimilative processes. Decreased destructive changes might just as well account for the two effects above noted. Furthermore, the manner in which stimulation could bring about increased assimilation was left wholly in the dark. Nevertheless, the theory has been widely accepted. It has recently received support by Meek and Eyster[101] who claim to have obtained a positive electrical variation in the turtle's heart when the vagus was stimulated, using the Einthoven galvanometer as the indicator of the electrical changes. Einthoven himself has not published any research on this point especially.

Verworn,[146] in his "biogen" theory, has stated more definitely a hypothesis. From chemical and biological studies he conceives protoplasm to contain unstable molecules, or biogens, which are continually undergoing assimilation and dissimilation. The doctrine asserts that under certain conditions of stimulation the assimilative processes may diminish or prevent dissimilation, which liberates energy in the cell. Whether we have inhibition or excitation depends, according to Verworn, upon the preponderance of one or the other side of metabolism. There are great difficulties in the working out of this theory and we shall see that later Verworn in his revised hypothesis simplified matters very satisfactorily.

Meltzer[107] in 1899 and 1902 reviewed the various instances of inhibition in the animal body, calling attention to the ubiquity of the process. He agrees in the main with those who favor the trophic theory, but he does not go so far as to say that inhibition is directly implicated in the process of anabolism, and still less that inhibitory nerves control this entire process. He refrains from being so specific, holding that it is more satisfactory to assume that the "two components of irritability, excitation and inhibition," are concerned only with the transformation of potential into kinetic energy, not with the creation of material nor with specific forms of expenditure. In his second paper Meltzer restates his belief that irritability is the resultant of two antagonistic forces, excitation and inhibition. Vital processes can no more go on without the one than the other. He points out the importance of inhibition in the field of pathology as well as in physiology. The emphasis he places upon the lack of attention inhibition has received by pathologists is well merited. The defect in Meltzer's theory is that it throws no light upon the way in which inhibition offsets or checks excitation.

In 1903 McDougall[97] brought out an interference theory. It was based on the behavior of visual images and made applicable to the reactions of antagonistic muscles. The theory attempted to explain inhibition in the nervous system and did not deal with the inherent nature of the process except in so far as it inculcated fatigue of the synapses. According to his scheme, inhibition is the result of competition between the inhibiting and the inhibited tracts, the former drawing to itself part of the energy liberated by the latter. The theory has much to commend it. For the details reference is made to the original article.

In 1905 MacDonald[96] published his theory based on studies of the action of salts upon nerve function. The theory cannot be stated satisfactorily in few words, but essentially it is that the processes of excitation and inhibition are conditioned by the changes in concentration of salts upon the surface of the colloidal particles in nerve tissue, *e.g.* the axis cylinder. It is suggested that inhibition is a condition in which the colloidal particles undergo diminution in size and the salts become more firmly packed upon their surfaces. Inhibition is the state in which movement of salt molecules is at a minimum and in excitation the movement is at a maximum. Macallum,[95] by refined microchemical tests, has been able to show that quantitative differences in the potassium salts exist at different points in the tissues. His findings support MacDonald's theory.

The well-known depressant action of potassium has been correlated with inhibition, especially of the heart (see Fig. 3408) and thus the problem has been penetrated further. Howell and Duke[72] have shown that stimulation of the vagus in the dog causes a liberation of potassium in diffusible form in the auricles. They propose a more specific theory of inhibition, then, as far as the heart is concerned. They suggest that stimulation of the vagus causes a cleavage of some sort which sets free potassium in soluble form. If this occurs in the region of the pacemaker of the heart we have a simple explanation, as far as it goes, of vagus action on this organ. An interesting fact in this connection is that calcium salts seem to be necessary for this action of the vagus. Evidence of this function of calcium has been obtained by several. Hagan and Ormond[61] state that the action of calcium lies in its relation to the production and conveyance of the vagus impulse to the heart muscle rather than to the inhibitory process itself which occurs within the heart muscle. Hagan and Ormond give the literature.

Other ions have been thought to take part in the inhibitory phenomena. Meltzer and Auer[108] have for several years, in various papers, pointed out the inhibitory action of magnesium. Their systematic study of the action of magnesium salts was started with the feeling that the magnesium ion had an essential part in inhibition. Their latest experience with magnesium is still favorable to this view. This action of Mg is antagonized by Ca, which is also antagonistic to Na. NaCl solutions will cause striated muscle to undergo rhythmic twitching, and Loeb[93] has shown that this is prevented in the body by the presence of Ca, or Ca and K.

The most recent attempt to explain inhibition is that of Verworn, who now sees in this process a close relation to the refractory period and fatigue of muscle and nerve. It is an interesting fact that fatigue should now again receive so much consideration more than fifty years after Schiff suggested that inhibition and fatigue are one and the same thing. Verworn's conception has been set forth in several papers, and has lately been put into English.[147(a)] He states that years of search have disappointed him in his effort to discover any evidence that stimulation increases assimilative processes, except the stimulation caused by the introduction of food into the cell. This obviously cannot be the stimulus acting in cases of inhibition as stimulation by food is never momentary. From his own observations and those of many others, among whom may be mentioned Fröhlich, Thörner, Gotch, Keith Lucas, Lodholz, Veszi, Tiedemann, Winterstein, Heaton, Bondy, Pütter, Jennings, Sherrington, Samojloff, and Boruttau, he is led to conclude that a relative lack of oxygen is the primary cause of the development of those states of living matter characterized by decreased disintegrative changes. Verworn, unable to satisfy himself that stimulation as it ordinarily occurs is capable of producing increased assimilative change, investigated the conditions that bring about decreased dissimilation, as it is evident that this state in metabolism must result in decreased functional activity. He became convinced that diminution of oxygen is the main factor in inducing the refractory period of muscle and nerve. This decrease in oxygen is only relative, that is, in the disintegrative changes the consumption of oxygen is for the moment greater than the supply entering the acting tissue. The intensity of the oxydative reaction is largely conditioned by the intensity of the exciting stimulus acting upon the unstable bodies of protoplasm ("biogens") and by the rapidity of repetition of the stimulation. As waste products accumulate and available materials are used, irritability decreases. This is the refractory period. Prolongation of this refractory state is fatigue. Inhibition consists in a reduction of irritability below the perceptible threshhold of response to a given stimulus. It depends upon a continual lessening of the decomposition processes. According to this, inhibition is a relative fatigue. The argument is extended to explain the interference of stimuli, the phenomena of depression and of narcosis. It must be said that the whole theory as presented by Verworn is well founded upon experimental evidence. Forbes,[50] in 1912, has also independently arrived at the conclusion that inhibition is a suppression and not a stimulation. He sees no evidence that it can arise by increased assimilation.

Appropos of this theory of inhibition as set forth by Verworn, mention may be made of inhibition as an explanation of the limitation of growth. (See Loeb,[93(a)] Lilly[93(b)] and Minot[111(b)] for references to the literature.) Loeb and others have shown that if the fertilized eggs of sea urchins, starfish, annelids, frogs, and fishes are deprived of oxygen, no nuclear division is possible. Loeb thinks that this effect of the lack of oxygen is probably true for the ova of all animals. He has also shown that if eggs, fertilized or unfertilized, are allowed to segment, oxidation is increased many fold. In the maturation of the ovum oxygen is likewise necessary. Several biologists (Loeb, Lilly, F. R., Boveri, Batallion, and others) have assumed that some sort of inhibitory substance, or mechanism, is present in the egg, retarding its development, and it is believed by some that the process of division, after fertilization for example, is initiated by the elimination of the inhibiting factor. The nature of this factor is problematical, however. The same idea has been expressed in the literature dealing with cell growth in general. Thus, Minot alludes to the possibility of inhibiting forces limiting the growth of normal tissue cells, and it has been suggested, among other theories, that in malignant growths the cells constituting the tumor have escaped from the inhibitory control (V. Dungern and R. Werner, "Das Wesen der bösartigen Geschwülste. Eine biologische Studie," Leipzig, 1907, p. 159).

It must be admitted that the exact nature of inhibition is yet a problem far from solution, but perhaps not any farther from solution than the exact nature of excitation. The two processes are metabolic and intimately connected, and light thrown upon the one may be expected to illuminate the other.

The author acknowledges, with thanks, his indebtedness to Drs. Sherrington, Simpson, Einthoven and Wieringa, Robinson and Draper, Angyan, and Howell for figures used in the text. M. Dresbach.

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Innervation means the nerve supply and nerve control of some part or other of the organism. This definition embraces every kind of nerve influence and includes therefore the exciting as well as the inhibitory action on the part concerned. It moreover includes the activity of all those sensory (afferent) nerve or nerve apparatuses that serve to transmit sensory impulses from the organ concerned to nerve centers of both the peripheral (sympathetic) and the central nervous systems. If, however, any nerve or nerve apparatus, although situated in the immediate vicinity of a given organ or even within the organ itself, has no connection with the elements of the same, and therefore exerts no influence whatever on its function, such nerve or nerve apparatus must be excluded from the "innervation" of this organ. Usually when we speak of the innervation of an organ we include the nerve control of all its tissues. For instance, innervation of the small intestine means the nerve control over its glands, muscles, blood-vessels, and connective tissue, as well as that nerve supply which conveys sensory impressions from the intestine to nerve centers of the peripheral, and central nervous systems. If we speak of the "innervation" of a muscle the term should include the nerve control over its blood-vessels and its sensory supply, although often the motor action on the muscle fiber alone is meant.

Not only the nerves and nerve apparatus directly connected with the part or organ concerned should be included in the definition of its innervation, but also those connected with it more remotely, as long as they have any control over it. For instance, the arm of the cerebral cortex belongs within the domain of the innervation of the arm, although when speaking of the latter we more frequently have in mind the peripheral nerves and nerve apparatus connected with it.

B. Onuf (Onufrowicz).

Inoscopy.—Jousset[1] writing in 1903, described a process for the detection of tubercle bacilli in serous and cerebrospinal fluids which is termed "inoscopy." The process is essentially of a digestive nature. The fluids are drawn into sterile flasks and allowed to coagulate; this entangles the bacilli in the fibrin network of the clot and extracts them from the fluid. The clot is then digested according to the technique given and the sediment is stained for tubercle bacilli in the customary manner.

Wood[2] mentions that the process is positive in more than fifty per cent. of the cases of tuberculous meningitis. While the method is undoubtedly applicable to the cerebrospinal fluid in the detection of tubercle bacilli, yet the writer has never found it necessary to digest the clot of a cerebrospinal fluid. The clot that forms in spinal fluid is of a fine veil-like nature and it is only necessary to make a dry preparation of the clot and stain. The results have been shown to run higher than the figures given by Wood, safely seventy to seventy-five per cent. This method has also been used for the detection of tubercle bacilli in the blood, but when one considers the controversy that exists at present concerning the finding of acid-fast bacilli in blood and distilled water it has a tendency to make one skeptical of the blood findings. There was a good deal of work done in this field, *i.e.* searching for acid-fast bacilli in the blood, prior to 1901. Ewing threw considerable doubt on the work that has been done up to 1901. The subject was prominently brought forward again in 1908 and will be discussed later in this article.

The Technique of Inoscopy.—The fluid should be aseptically drawn into sterilized Erlenmeyer flasks. According to Musgrave at least 100 c.c. should be drawn, other authors give as high as four or five liters. It is allowed to clot, the fluid being gently shaken to facilitate contraction of the clot. The clot is then washed on a piece of sterile gauze or linen over a funnel end until all the serum is cleaned away; after which the clots are placed in the digesting solution. The amount of fluid will, of course, vary with the individual case, the size and number of clots determining the amount. In any event enough fluid should be used to insure digestion. In the average case this will be about 30 to 40 c.c.

The clot in this fluid in a sterile flask is then placed in an incubator at 37° C. until digestion is complete, usually about two to four hours. After it is thoroughly digested the mixture is placed in sterile centrifuge tubes and centrifugalized for ten or fifteen minutes. The supernatant fluid is poured off and a loop-full of the sediment is placed upon a cover-glass and stained in the usual manner after being fixed with gentle heat. Musgrave calls attention to the fact that the preparation must not be subjected to undue decolorization: he suggests one-half to three-fourths of a minute with Gabbett's solution.

The formula for the digesting solution is:

Pepsin		2 gm
Pure glycerin,		
Strong HCl	♏♏	10 c.c.
Sodium fluoride		3 gm
Distilled water		2,000 c.c.

Shali says in this connection; "a freshly prepared pepsin (HCl solution) apparently serves as well as the formula given, but will not keep so well on standing."

It is a point mentioned by all writers upon the sub-

ject that the tubercle bacilli will lose some of their characteristic morphology under this process and appear shorter, broader, and paler red than the tubercle bacilli usually seen in the sputum.

The bacilli not only occur singly but are frequently found grouped. There are usually seen a good many undigested nuclei in the sediment. Inoscopy may be preferable in those cases where a very rapid diagnosis is desirable or necessary, but under all ordinary circumstances animal inoculation is not only much more reliable but is not open to the same criticisms or possibilities of error.

Antiformin Method.—There are two other processes of digestion of material as a preliminary to the detection of tubercle bacilli that may be mentioned. While they were not originally included in the term, nor are now usually referred to in connection with inoscopy, they are nevertheless rightly classed there. Reference is made to the antiformin method of demonstrating tubercle bacilli in the sputum and blood.

In 1908 Uhlenhuth and Xylander discovered that antiformin possessed the power to dissolve all bacteria except those which are acid-fast, to which class tubercle bacilli belong. Applying the process to the sputum they found that in addition to the bacteria the great mass of sputum was dissolved. This method of finding the tubercle bacilli in the sputum has proven a very valuable aid, it being possible to demonstrate by this method the bacilli in about forty per cent. of the cases where they are so scarce as not to appear in an ordinary preparation.

Antiformin is a clear liquid compound of equal parts of fifteen per cent. solution of sodium hydrate and liquor sodæ chlorinatæ (B.P.) (Patterson[3]).

The liquor sodæ chlorinatæ is prepared as follows:

Sodium carbonate	600 gm.
Chlorinated lime	400 gm.
Distilled water	4,000 c.c.

Dissolve the sodium carbonate in 1,000 c.c. of distilled water. Triturate thoroughly the chlorinated lime in the remainder of the water. Filter. Mix the two solutions and filter again. There is obtained an alkaline, almost colorless liquid with a strong chlorine odor.

Williamson[4] calls attention to certain precautions that should be observed:

1. The antiformin must be fresh and active and should be kept in well-stoppered bottles in the dark. Any sample which does not readily, in the proper concentration, dissolve the sputum when brought to the boiling-point is worthless. Extemporaneous solutions are often inefficient. It is better to procure the antiformin in original packages.

2. The emulsification must be thorough and complete. This is secured by vigorous shaking and usually requires about two minutes.

3. The fixative should be egg-white to which 0.5 per cent. carbolic acid has been added as a preservative. Glycerin fixatives are not suitable. Many workers, however, obtain excellent results using some of the original sputum as a fixative. In many instances this is really to be preferred, in that it gives one an opportunity to study at the same time the composition of the sputum as a whole.

It is to be borne in mind that antiformin does not kill the tubercle bacilli and all liquids poured from the solutions and the slides after studying should be disinfected carefully.

There are given here two techniques which the writer has found most useful.

Loeffler's method (from C. S. Williamson[4]).

1. To a given amount of sputum s added an equal amount of fifty per cent. antiformin and the mixture placed in a Jena glass flask and brought to a boil.

2. To each 10 c.c. of the resulting solution is added 1.5 c.c. of a mixture of one part chloroform and nine parts alcohol. This is violently shaken (best in a 25 c.c. glass-stoppered measuring cylinder) for about two minutes, or until complete emulsification has taken place. This has for its purpose the impregnation of the lipoid capsule of the bacilli with the chloroform, whereby their specific gravity is greatly increased. The alcohol assists in the emulsification.

3. This emulsion is now placed in a centrifuge tube and revolved at as high a rate as possible for about fifteen minutes. In the bottom of the tube will be found a few drops of clear chloroform, then a firm narrow disc of sediment which is sufficiently tenacious to be capable of removal *en masse*, and above this a fairly thin clear fluid. This small disc, containing the undissolved matter and the tubercle bacilli if any are present, is removed *en toto*, and placed on a slide, the excess of antiformin being removed by a bit of filter paper. A small drop of egg-white is added and well mixed with the platinum loop and the whole spread between two slides. These are fixed in the usual manner by passing through the flame and are stained as may be desired. Loeffler preferred carbofuchsin, decolorizing with a three per cent. hydrochloric acid alcohol and counterstaining with 0.1 per cent. aqueous solution of malachite green.

Boardman[5] gives the following technique:

1. Fifteen or twenty cubic centimeters of the sputum are placed in a conical specimen glass and antiformin is added sufficient to make a twenty per cent. solution of the antiformin.

2. Allow this to become homogeneous and of a watery consistence and add an equal volume of ninety-five per cent. alcohol. The addition of the alcohol facilitates sedimentation since it lowers the specific gravity of the mixture to less than 1.000. This is stirred thoroughly and allowed to stand until sedimentation is complete.

3. Pour off clear supernatant fluid and make a smear of the sediment, using some of the original sputum as a fixative.

4. Fix and stain in the usual manner.

Patterson[3] also describes a technique for the use of antiformin. It requires specially treated glass-ware and several washings of the sediment with distilled water and salt solution. In addition to this being more cumbersome the method brings in the distilled water acid-fast bacilli which is a source of error, unless one examines the water for acid-fast bacilli before using.

In 1909 Rosenberger gave his technique for the use of antiformin in finding tubercle bacilli in the blood of persons suffering from the different forms of tuberculosis. This technique was later modified by Kurashigi and Schnitter and is as follows:

Draw 1 c.c. of blood from one of the arm veins into a sterile centrifuge tube containing 5 c.c. of three per cent. solution of acetic acid. Allow this to stand for thirty minutes; centrifugalize thirty minutes; decant the supernatant fluid (into a disinfecting solution) and dissolve the sediment with 5 c.c. of concentrated antiformin; when dissolved add 5 c.c. of absolute alcohol and centrifugalize again for thirty minutes; again decant and wash the snow-white sediment with distilled water; centrifugalize again for thirty minutes, decant the supernatant fluid and spread the sediment upon a clean glass slide, fix and stain.

The bacilli when found usually occur in loose clumps.

This work of Rosenberger was, as mentioned above, first published in 1909 and in it he claimed to have found tubercle bacilli in the blood stream of all people suffering from tuberculosis; in his series were included cases of pulmonary and bone tuberculosis, tuberculous pharyngitis, laryngitis, and lupus. Forsyth[7] and Petty and Mendenhall[8] claimed to have confirmed Rosenberger's findings. Brem later reported the finding of an acid-fast bacilli in all specimens of laboratory water examined in the government laboratories in Panama. He estimated the number of acid-fast bacilli in one specimen of distilled water at 30,000. This article was published under the

caption, "Investigation of Blood for Tubercle Bacilli; Contamination of Distilled Water with Acid-fast Bacilli a Source of Error" and caused a great deal of scepticism regarding Rosenberger's work. However, in 1913 Roger and Murphy[10] come to the front supporting Rosenberger's work using the Kurashigi-Schnitter technique. They report the finding of "an acid-fast bacillus in all cases identical morphologically with the tubercle bacillus." They do not state whether this bacillus was pathogenic to guinea-pigs; a point in Brem's work. The acid-fast bacilli he found in distilled water were not pathogenic to guinea-pigs. Rogers and Murphy state, however, that they examined the distilled water used for acid-fast bacilli and were unable to demonstrate any. The number of cases in their series was twenty-six, all of the incipient pulmonary form.

Care has been taken here to include most of the recent literature on the subject, that those interested might look the matter up for themselves and reach their own decisions. One more reference might be added, Brauer.[11]

It can be safely said, at least, the finding of an acid-fast bacillus in the blood stream when the technique uses distilled water is, after Brem's work, to be accepted with some mental reservation until more work is done upon the subject. H. B. Hiatt.

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Inosite, $C_6H_{12}O_6$, is a hexahydroxy benzene and occurs in many organs and tissues of the body as well as in traces in normal urine. It undergoes lactic acid fermentation. It occurs in many cereals in combination with phosphoric acid. F. P. U.

Insane, General Paralysis of the.—See *Paresis, General.*

Insanity.—See *Mental Diseases.*

Insect Carriers of Disease.—This article has been given a title in popular terms, instead of in correct technical terms. The subject here discussed would be covered by the title—Arthropoda in their Relation to the Transmission of Parasitic Diseases. The greater number of those animals of the phylum (sub-kingdom) Arthropoda which are at present known to play an important, in some cases an indispensable, rôle in the conveyance of disease are of the class Hexapoda (Insecta), possessed of three pairs of legs and undergoing in their life cycle a characteristic metamorphosis from ovum to larva, pupa, and imago or adult. But other arthropoda than those properly called insects, namely, some of the class Arachnida, which have four pairs of legs and no metamorphosis, in which class are included all the ticks, and even some of the class Crustacea, bear a part in propagating the parasites of certain diseases similar to that borne by true insects in propagating others.

The word *carrier* as applied to an insect in connection with the transmission of disease has a special and limited meaning. An insect or other arthropod which is a simple carrier of infection has no more specific relation to the spread of disease than the word carrier implies. To illustrate: The house fly, *Musca domestica*, is a carrier of *Bacillus typhosus* and a spreader, therefore, of typhoid fever. The fly bears no specific biological relation to the bacillus, nor to the infected patient, nor to the uninfected person to whom the disease is indirectly conveyed by the fly's agency. The fly rests its feet upon typhoid feces in an unscreened privy or elsewhere, typhoid bacilli cling to them and are subsequently wiped off on the surface of solid foods or washed off in milk which is to be consumed by man. The rôle of the fly in the spread of typhoid fever is an indirect or accidental one. Its feet and other parts of its body serve just as a cotton swab serves to transfer bacteria from a throat to a culture tube. The fly acts, then, as an indirect carrier of typhoid fever, having no more a specific biological relation to *B. typhosus* than a cotton throat swab has to *B. diphtheriæ*. *Musca domestica* cannot bite; it has no biting mouth-parts, its proboscis is soft and sponge-like, and biting is for it a mechanical impossibility. As distinguished from the biting and blood-sucking flies, it is numbered among those called the merely noxious Muscidæ, which live in association with man and which alight and feed alternately upon infected material and upon the food of man. All these flies, as well as cockroaches and some other insects, spread bacterial infections as indirect carriers not merely with their feet but in the spreading about of their infected excrement.

When we come to consider the rôle played by biting and blood-sucking arthropods in the spread of bacterial infections we find them acting as *direct carriers*. The most impressive example of an insect serving as direct carrier of a bacterial infection is found in the transmission of bubonic plague from rat to rat and from rat to man by the rat flea *Læmopsylla cheopis*. This blood-sucking insect takes into its stomach some plague bacilli along with the blood it sucks, and while in its body the bacilli are protected from the desiccating effects of air and sunlight, kept by the flea's contact with the body of a warm-blooded animal in a temperature favorable to incubation, and supplied with animal blood as a nutrient medium. In these conditions the plague bacilli maintain their virulence for a considerable time in the flea's body and probably multiply there. They are therefore constantly discharged with the flea's feces upon the skin of the next host and rubbed or scratched into the flea bites on that host by the flea or by the host himself. The rat flea, in its migratory parasitism, is thus the usual direct carrier of plague from rat to man.

From man to man, other biting and blood-sucking insects of the orders Diptera (flies and gnats), Siphonaptera (fleas), Hemiptera (bugs) especially the family Cimicidæ or bedbugs, and Siphunculata (lice) are qualified to serve as direct carriers of plague or of many other bacterial infections from man to man. And beside these members of the class Insecta some biting and blood-sucking arthropods of the class Arachnida, especially the order Acarina (mites and ticks) must be regarded as possible direct carriers of bacterial infections to man and to lower animals.

The function performed by the non-biting indirect carriers is accidental in its nature. They do not in any special way conserve and protect the infectious bacteria which they carry, nor are their habits such as to insure that these bacteria shall arrive at the goal of infecting man or another animal. According to present views, the most important indirect carriers are the merely noxious Muscidæ more or less closely associated with man in his habitations, belonging to the genera *Musca* (house flies), *Calliphora* (blue bottles), *Lucilia* (green bottles), *Pycnosoma*, etc. To these may be added those Muscidæ which bite but do not suck blood, the genera *Auchmeromyia* and *Cordylobia*, and a few flies of other families as the

Sarcophagidæ (meat flies) and the Scatophagidæ (dung flies).

Under the head of direct carriers come all the biting and blood-sucking Muscidæ. Of these the most important are the stable-fly of world wide distribution, *Stomoxys calcitrans*, and the many species of the genus *Glossina* in Africa. Other genera of Muscidæ which both bite and suck blood are *Hæmatobia*, *Lyperosia*, *Stygeromyia*, *Hæmatobosca*, *Bdellolarynx*, and *Philæmatomyia*. Of the pupipara or tick flies, the Hippoboscidæ and the Nycteribidæ are biters and blood-suckers. In the list of probable direct carriers of bacterial infections we must include the Tabanidæ (gad-flies), the Chironomidæ (midges), Cecidomyidæ (gall-midges), Blepharoceridæ (net-winged midges) Psychodidæ (owl midges) and the Culicidæ (mosquitoes) except those that do not bite. Leaving the Diptera and turning to other orders of biting and blood-sucking insects, we have the Siphonaptera (fleas), the Hemiptera (bugs), and the Siphunculata (lice). The bites of all these latter, beside being irritating, are likely to become infected with cocci and produce impetigo. So much for the Insecta. Turning to the class Arachnida, order Acarina, we find the families Ixodidæ (hard ticks), Argasidæ (soft ticks), and the Dermanyssidæ, Trombididæ, and Sarcoptidæ, the last three burrowing in the skin instead of sucking blood, but opening thereby a way for bacterial infection (*e.g. Sarcoptes scabiei*).

When we consider the equipment of the biting and blood-sucking insects and acarines, each of them may be likened to an animated aspirator with trocar and cannula, on a small scale. It seems reasonable to think that many of them may presently be convicted of playing important parts in the transfer of bacterial infections, as the rat flea has already been convicted of doing. It may be safely assumed, however, with regard to the relation of a blood-sucking arthropod to the infecting bacterium carried by it, that such relation will in no case be found to be an indispensable one. The simple life cycle of a bacterium, multiplying by division anywhere that it finds necessary nutriment and favorable temperature, or retaining its life and virulence under unfavorable conditions without multiplying, precludes the idea that any insect could be an indispensable host for its propagation. To accept this is to understand the sense in which the word *carrier* is used when we say that any insect serves as a carrier, and only as a carrier, of a certain disease.

We now turn to the more interesting and more complicated relations of various arthropoda to the propagation of diseases caused by animal parasites. In approaching this subject it will be well to refer briefly to some of the terms employed. Parasites are temporary or stationary, periodical or permanent. They are ectoparasites or epizoa, or they are endoparasites or entozoa. These terms are self-explanatory and it is assumed that they are familiar. An animal normally of a free-living kind may be introduced into the body of another animal and, finding there an environment in which it can survive for some time, become for the time being a parasite. In these circumstances the parasitic animal is said to be an occasional or accidental parasite. It sometimes happens that an animal parasite invades the body of some animal other than its usual or normal host. The animal so invaded is then called an unusual host and the parasite is called for that host a chance parasite. In the cases of many of the parasitic protozoa a parasite must pass through two different stages of its life cycle in two different animals. The animal in which complete development of the sexual stage of the protozoan parasite takes place, with reproduction by sporogony, is called the determinate host (definitive or primary host); the animal in which an incomplete, immature, asexual stage in the development of the parasite takes place, with or without schizogony, is called the intermediate host (intermediary or secondary host). The parasitic protozoans which produce disease in warm blooded animals are not accidental parasites. They have no free living existence, their parasitism is obligatory; deprived of their intermediate or determinate hosts they must perish. Generally speaking the normal host is obligatory for the parasite and it is not found in unusual hosts as a chance parasite. But in the cases of some of the protozoan parasites, any one of several species, sometimes belonging to different genera, can serve as normal hosts for the same parasite. This is true as regards both intermediate and determinate hosts. Arthropods serve as hosts and also as carriers not only for protozoan parasites but also for a considerable number of the parasitic metazoa, particularly for parasitic helminthes. Thus *Culex fatigans* serves as intermediate host for *Filaria bancrofti*. In connection with animal parasites and arthropod hosts, it is to be noted that the parasite may become hereditary in the host and be further transmitted only by a second generation of that host. This is the case with *Babesia bigemina* of Texas cattle fever in *Margaropus annulatus* the tick which transmits it from ox to ox.

Another variation in the life of parasites in arthropod hosts is illustrated in *Parachordodes tolosanus*, one of the so-called "horse-hair worms" found in the water of swamps and stagnant ditches. Four cases have been reported in which this worm was an accidental parasite of man. The first larva of this worm enters the larva of the alder-fly, *Sialis lutaria*, in which it lives during the first winter and passes over to the imago of the same insect which is eaten by the beetle *Pterostichus niger*, in which the larva undergoes a change, becoming a second larva, which lives in the beetle during the second winter and finally escapes into the water, about twenty months after hatching, and soon becomes an adult. This Parachordodes is not itself of any pathogenic importance as regards man, but it is of interest as an illustration of a metazoan parasite requiring two arthropods of different orders as intermediate hosts, and spending nearly a year in each to complete the larval stage in the life of one individual parasite. This suggests that some of the known parasites of man and domestic animals whose life cycles have not been completely traced out may require more than one intermediate host.

When a certain animal parasite is constantly to be found in some species of host, whether pathogenic or innocuous in that host, and when it is constantly taken from that host by some blood-sucking insect which transmits it to another species of animal, the first animal host which thus affords a constant source from which the insect carrier or host can draw a supply of the parasite is called a *reserve* or *reservoir* of the parasite. The parasite is sometimes innocuous in the reservoir animal (as *Trypanosoma bracei* in various members of the antelope tribe in Africa), and sometimes pathogenic (as *Trypanosoma equinum* in the South American water rat, *Hydrochærus capybara*). The discovery of the reservoir for *Trypanosoma gambiense* would probably afford a solution for the problem of eradicating the fatal sleeping sickness of man in Africa.

It is not within the scope of this article to consider those arthropods which cause symptoms by reason of a venom secreted by the arthropod itself and introduced by its bite or sting, nor those such as *Chrysomyia macellaria*, the screw worm fly, the various (Estridæ (bot-flies), etc., whose eggs implanted in the skin or the intestines of man or other animals cause these latter to serve as hosts for their larvæ with or without the production of inconvenient symptoms, nor those Sarcopsyllidæ (jiggers) and Sarcoptidæ (mites) whose adults embed themselves in the skin. We confine our attention to those arthropods which serve as hosts or carriers of animal parasites which they transmit to man or to other warm-blooded animals living in association with man. In enumerating

such arthropods, to avoid unnecessary elaboration and multiplication of zoological terms all classifications and divisions such as subclasses, suborders, sections, superfamilies, groups, etc., will be omitted. All such terms are elastic and variable and at no time is there a universal agreement in their use among zoologists. The international rules for nomenclature do govern, however, in the determination of phylum, class, order, family, genus, and species and these terms only will be used for the identification of each arthropod mentioned. For the sake of brevity the names of discoverers or classifiers, with dates, after the names of genera and species, will be omitted.

For complete biological details of the life cycles of the parasites mentioned the reader is referred to appropriate titles elsewhere in this HANDBOOK, to recent works dealing with tropical medicine and parasitology, and to the current literature on these subjects. No further description of the development of a parasite in an insect transmitter will be given here, as a rule, than to state whether the insect is a determinate host, an intermediate host, or a simple carrier, with a brief reference in some cases to the *modus operandi* of transmission. When it is not possible to say whether the arthropod in question has the biological relation of a host to the parasite or acts as a simple carrier, it will be stated simply that the arthropod transmits the parasite in question.

The important arthropods known to be transmitters of animal parasites to man and to other warm-blooded animals living in association with man, are as follows:

Class CRUSTACEA (aquatic arthropoda), Order Copepoda, Family Cyclopidæ.—*Cyclops quadricornis* and probably other species of cyclops serve as intermediate hosts for *Filaria medinensis* (Guinea worm). Man swallows the infected cyclops with his drinking water. In the hydrochloric acid of the stomach the cyclops is promptly killed and the filarial larva, stimulated by the acid, pierces the chitinous cuticle of the cyclops and the stomach wall of the determinate host, man, and develops to mature male and female forms in his tissues.

Class ARACHNIDA, Order Acarina (mites and ticks), Family Argasidæ (soft ticks).—*Argas persicus* transmits *Spirochæta marchouxi* to fowls in Egypt, Brazil, and elsewhere, and *Sp. neveuxii* to fowls in Senegal. It also transmits to man, in Persia, a disease the parasite of which has not been identified.

Ornithodorus moubata transmits *Spirochæta duttoni* to man, causing the African tick fever, and *Sp. rossii* causing a similar disease of man in East Africa. This tick is suspected of transmitting *Filaria perstans* to man.

Family Ixodidæ (hard ticks).—*Eurhipicephalus appendiculatus*, the brown tick of South Africa, transmits *Babesia bigemina* (*Piroplasma bigeminum*) to cattle, causing the so-called Texas cattle fever, or tick fever of cattle. This tick also transmits *Babesia parva* to cattle, causing the East Coast fever of cattle in Rhodesia. The larva transfers the infection to the nymph and the bite of the infected nymph infects other cattle.

E. simus also transmits *B. bigemina*, as above.

E. evertsi, the red-legged tick of horses in Europe, Asia, Africa, and South America transmits *Babesia equi* to horses, donkeys, and zebras.

E. sanguineus, the common dog tick, widely distributed, transmits *Babesia canis* to dogs. It also transmits *Hæmogregarina canis* to dogs. The nymph, in which the infection is hereditary, and the bite of which transmits the infection to another animal, is sometimes called *Phailixodes rufus*.

E. bursa, in southern Europe, Africa, and the West Indies transmits *Babesia ovis* to sheep, causing the disease known as "heart water," the parasite being carried from the adult female through her eggs to the adult tick of the next generation which alone transmits the infection to other sheep.

Margaropus annulatus (*Boophilus bovis*), a cattle tick widely distributed throughout the world, transmits *Babesia bigemina* to cattle, causing the babesiasis known as Texas cattle fever. The blood-sucking female infects her own egg and the blood-sucking larva hatched from this transmits the Babesia in biting other cattle.

M. decoloratus, the blue tick of South Africa transmits both *Babesia bigemina* and *Spirochæta theileri* to cattle.

Dermacentor reticulatus in Russia transmits a Babesia to horses, a parasite not yet fully identified for which the name *B. ninense* has been proposed.

D. occidentalis and *D. venustus* in the northwestern United States transmit the infection of Rocky Mountain spotted fever to man. The parasite is probably some species of Babesia.

Hæmophysalis leachi, the South African dog tick, transmits *Babesia canis* to dogs, the parasites entering the ova of the infected ticks, from which develop nymphs which are infected. These infected nymph forms bite the dog without infecting it, but on developing into mature ticks their bites infect the dog. The ticks of the second generation have thus acquired the infection in a truly hereditary manner. It is evident too that the tick is a host and not a mere carrier.

Ixodes ricinus, the so-called castor-oil tick, because of the resemblance of the pregnant and replete female to a castor-oil bean, a tick widely distributed in Europe and North America, is another transmitter of *Babesia bigemina* to cattle in America and of *B. bovis* to cattle in Europe.

Amblyomma hebræum, the variegated tick of Cape Colony, transmits *Babesia ovis* to sheep, causing "heart water."

Class HEXAPODA or INSECTA, Order LEPIDOPTERA (moths), Family Pyralidæ.—*Asopia farinalis* (*Pyralis farinalis*) the meal moth is the intermediate host for the cysticercus stage of *Hymenolepis diminuta*, the tape-worm of rats and mice, the adult of which sometimes infests man as determinate host (a chance parasite).

Order EUPLEXOPTERA (earwigs), Family Forficulidæ.—*Anisolabis annulipes* also serves as intermediate host for *H. diminuta*.

Order COLEOPTERA (beetles), Family Scarabæidæ.—Some species of the genera *Melolontha* and *Cetonia* are intermediate hosts for *Gigantorhyncus gigas*, a nematode parasite of pigs.

Order ORTHOPTERA, Family Blattidæ (cockroaches).—*Periplaneta orientalis*, the oriental cockroach, serves as intermediate host for *Spiroptera sanguinolenta*, a nematode parasite of dogs.

Order SIPHUNCULATA (lice), Family Pediculidæ.—*Hæmatopinus spinulosus*, the rat louse, is the transmitter of *Trypanosoma lewisi* from rat to rat.

Family Ricinidæ.—*Trichodectes canis*, the dog louse, and *T. subrostratus*, the cat louse, are the intermediate hosts for *Dipylidium caninum*. The lice swallow the oncospheres lying in the fur and on the skin about the anus of the animal, and develop the scolex in their bodies. The dogs and cats reinfect themselves by biting and eating the lice.

Order HEMIPTERA (bugs), Family Cimicidæ.—*Cimex lectularius*, the common bed bug of the temperate zone. It is probable, but not proved, that this bug transmits *Spirochæta recurrentis* (*obermeyeri*) to man, causing relapsing fever.

Cimex rotundatus, the common bed bug of the tropics. This bug is believed to transmit *Leishmania donovani* to man, causing kala-azar, the dum-dum fever of India.

Family Reduviidæ.—*Conorhinus sanguisuga* of Brazil transmits *Trypanosoma cruzi* to man, causing a disease characterized by fever, adenopathy, and anemia.

Order SIPHONAPTERA (fleas), Family Pulicidæ.—

Ctenocephalus canis, the dog flea, and *Ct. felis*, the cat flea, serve as intermediate hosts of *Dipylidium caninum*, eating the onchospheres, developing the scolex, and being eaten in turn by the dog or cat which thus reinfects itself. These fleas sometimes jump from a dog or cat into a vessel of milk which is drunk by a child who thus becomes infected with *Dipylidium*. The common human flea, *Pulex irritans*, may serve similarly as intermediate host.

Order Diptera (flies, gnats, etc.), Family Psychodidæ (owl midges).—*Phlebotomus papatasii*, around the shores of the Adriatic, transmits to man the endemic fever known as "three-day fever" or "papataci fever," the parasite of which is not known. A similar fever is spread by *P. major* in Malta, and by *P. minutus* and other species in Africa and India.

Family Simulidæ (sand flies).—*Simulium*. About seventy species of this genus are known. The females bite and suck blood of both man and animals. They are suspected of being concerned in transmitting microparasitic disease to man.

Family Culicidæ (mosquito).—*Culex fatigans*, the common brown house mosquito of the tropics, is the usual intermediate host for *Filaria bancrofti*, which it receives in its larval state in the blood sucked from man and after a period of larval development in the thoracic muscles of the mosquito, transmits it again to man, the determinate host. *C. fatigans* also serves as intermediate host for *Filaria philippinensis* which it receives from and transmits to man. This mosquito also transmits from man to man the infection of dengue (break-bone fever), the parasite of which is not known.

Stegomyia calopus, a brilliantly marked black and white mosquito of the tropics and subtropics, found as far north as Boston on the Atlantic coast of the United States transmits from man to man the infection of yellow fever, the parasite of which is as yet unknown but is believed to be an ultramicroscopic protozoan. The mosquito becomes infected by biting the patient only within the first three days of the fever. Twelve days more must elapse before the mosquito can transmit the infection in biting another man. Eggs laid by the mosquito after the lapse of the twelve days carry the infection into the second generation of the adult mosquito. The life of a generation of *S. calopus* is about thirty days during which period the female lays seven batches of eggs. *S. calopus* is domestic in its habits, being bred chiefly in cisterns, empty bottles, etc., and being active in flight and biting only from about 3 P. M. to the following morning.

S. pseudoscutellaris is the usual intermediary host for *Filaria bancrofti* in Fiji.

Mansonia uniformis and *M. pseudotitillans* also serve as intermediary hosts for *F. bancrofti*.

The mosquitoes already mentioned are all of the culicine, as distinguished from the anopheline type.

Anopheles maculipennis is a determinate host for *Plasmodium vivax*, *Plasmodium malariæ*, and *Laverania malariæ*, each of which it receives from and transmits to man, the intermediate host; *P. vivax* causing tertian fever, *P. malariæ* causing quartan fever, *L. malariæ* causing subtertian, estivoautumnal, or pernicious fever.

The following anopheline genera and species serve similarly as determinate hosts and transmitters of the malarial parasites: *Anopheles bifurcatus, A. martini, A. pursati, A. vincenti, Cellia albimanus, C. argyrotarsus, Myzomyia culifacies, M. funesta, M. listoni, M. ludlowi, M. superpicta, M. turkhudi, Myzorhyncus barbirostris, M. constani, M. paludis, M. pseudopictus, M. sinensis, Nyssorhyncus lutzi, N. stephensi, N. theobaldi, Pyretophorus ardensis, P. costalis, P. pitchfordi.*

The following anopheline genera and species are intermediate hosts and transmitters of *Filaria bancrofti*: *Cellia albimanus*, *Myzomyia culifacies*, *Myzorhyncus barbirostris*, *M. superpicta*, *Pyretophorus costalis*.

Family Tabanidæ (gad flies).—*Tabanus tropicus* in India, Mauritius, the Philippines, etc., transmits *Trypanosoma evansi* to horses, causing surra. *T. striatus* and probably other species of *Tabanus* also serve as transmitters of the same parasite. *T. nemoralis* and *T. sugillis* in Algeria transmit a disease to dromedaries, the parasite being unknown. The Tabanidæ are suspected also of transmitting *Filaria loa* to man.

Hæmatopota pluvialis in Europe and other species elsewhere are suspected of being transmitters of disease like the closely allied genus Tabanus.

Chrysops dimidiata and *C. silacea* in Africa are intermediate hosts of *Filaria loa* which they transmit to man.

The other genera of this family, namely, *Cadicera* in South Africa, and *Pangonia* widely distributed over the world, are similarly suspected of being transmitters especially of trypanosomes and of filaria. Some of the many genera and species of Tabanidæ transmit *Trypanosoma nanum* to cattle along the White Nile and *Tryp. vivax* to cattle, sheep, and goats in the Cameroons.

Family Muscidæ (flies).—*Stomoxys calcitrans*, the common stable fly all over the world, is the type species of the genus. This and other species, among which *S. nigra* in Mauritius may be mentioned, transmit *Trypanosoma evansi* to horses and other animals in the East, causing surra. In South America, *Trypanosoma equinum* is transmitted by *Stomoxys* to horses, causing *mal de caderas*. The reservoir for this parasite, *T. equinum*, is a water rat, *Hydrochærus capybara* in which it causes a disease endemic in that animal. *Stomoxys* is also a transmitter of *Trypanosoma nanum* to cattle in the Sudan, producing in them a disease similar to nagana but less dangerous; it also transmits *Trypanosoma dimorphon* in the Gambia, causing a disease of cattle.

Glossina palpalis and other species of the genus *Glossina* (tsetse flies) are formidable biters and bloodsuckers whose distribution is limited to tropical Africa and Arabia. The many species of this genus are the principal transmitters of the trypanosomes which cause diseases of man and of valuable domestic animals in those parts of the world. *G. palpalis* transmits *Trypanosoma gambiense* to man, causing that human trypanosomiasis which in its hopeless final stage is known as African "sleeping sickness." The reservoir is undiscovered.

Glossina morsitans certainly, and *G. pallipides* and *G. fusca* probably, transmit *Trypanosoma brucei* to cattle in Africa, causing in them the rapidly fatal disease known as nagana. Various members of the antelope tribe are the natural hosts and reservoirs for this trypanosome which appears to be innocuous in them. For three days after sucking blood infected with *T. brucei*, *G. morsitans* can transmit the infection to a fresh animal in biting it, the fly acting in this case as a direct carrier and the trypanosome being transmitted unchanged. From the fourth to the tenth day the fly's bite is not infectious for a fresh animal. From the eleventh day onward to the forty-fourth) its bite is again infectious, the trypanosome having undergone a development stage in the fly which in this case has served as a true host in the transmission of the trypanosome.

Family Hippoboscidæ (tick flies).—These are degenerate flies parasitic on mammals and on certain birds. *Hippobosca rufipes*, parasitic on cattle, in the Transvaal, East Africa, and India, is the transmitter of *Trypanosoma theileri*, which causes the "gall sickness" of cattle in those regions. *Lynchia maculata*, parasitic on the pigeon *Columba livia*, transmits the hemosporidian parasite *Hæmoproteus columbæ* from infected to healthy pigeons.

It is believed that all the arthropods now known to be the usual hosts or carriers of parasites causing

disease in man, or in animals of domestic or economic importance to man, have been mentioned. The list will almost certainly be extended by further investigations. In the case of each disease that is spread by arthropods, the discovery of the transmitter has had results of vast practical value in connection with personal and public prophylaxis. In the clinical handling of the individual case, the importance of preventing the appropriate insect carrier from coming into contact with the infected individual must be realized. But it is in connection with public sanitation that a knowledge of the bionomics of parasites and their arthropod transmitters is of chief importance.

The necessary detailed instructions for a campaign for the destruction of insects and other pests cannot be given within the limits of this article. The public sanitarian charged with the duty of making such a campaign should first make a biological survey of the situation with which he is called upon to deal, and should base his requisition for necessary funds, his organization of personnel, his formulation of orders and his plans for carrying them out, upon a well-digested estimate of the situation to be handled.

J. F. Leys.

Insect Powder.—*Pyrethri Flores.*—The half-expanded flower heads of *Pyrethrum cinerariæfolium* (Trev.) Bocc. (*White* or *Dalmatian Insect Powder*) and of *Chrysanthemum roseum* Weber and Mohr and *C. Marschallii* Aschers, both called *C. coccineum* Willd. in the *Index Kewensis* (*Blue, Caucasian* or *Persian Insect Powder*), all of the family *Compositæ*. The Dalmatian species is greatly superior. All are native and very extensively cultivated perennial herbs of western Asia. The heads bear a close resemblance to those of the common daisy, the rays being white in the Dalmatian, blue in the Persian. Insect flowers reach the hands of the consumers entirely in the form of the yellowish or gray powders, and it is then extremely difficult to determine their purity or quality, which varies most widely. The quality is claimed to be best when the heads are just beginning to expand, but their collection at this time is not economical. It decreases progressively with their maturity, but the use of the mature or old flowers, being extremely difficult of detection, is obviously profitable, and constitutes the chief form of sophistication. Enormous quantities of the stems, which possess a very slight activity, are also ground with the flowers. Their presence is readily detected in the powder by the appearance of large whitish, glistening particles, chiefly of the fibers, and less readily by the greener color which they impart. The powder should have a clear greenish-yellow, but not a bright yellow color, the latter indicating curcuma, fustic, chrome yellow, or other coloring addition. It has a tea-like odor and an aromatic and bitterish taste. Its ethereal liquid extract, in the proportion of five parts of the filtered liquid to one of the powder used, should be of a handsome yellow, and on evaporation should yield a soft extract equalling 3.75 to 5.5 per cent. of the weight of the powder. Upon incineration, the powder should yield not more than 6.5 per cent. of ash, nearly all soluble in hydrochloric acid. These tests will determine the presence of nearly all of the very numerous adulterants which have been employed. Others are detected by the use of the microscope, but this requires considerable experience. A powder from flowers which have become too old exhibits characteristic seed tissues and yields considerable fat, of which there is but a trace in the young flowers. The powder is more active in proportion to its fineness.

No analysis of the constituents of insect powder yet made is conclusive as to the identity of the toxic agent. There are (1) volatile oil ranging up to 0.5 per cent. most abundant in the youngest flowers; (2) four to seven per cent. of resin, about two-thirds of it alcohol-soluble, the rest ether-soluble; (3) fat, from a trace in the youngest flowers to a considerable amount after the seed has formed. With these are ordinary plant principles. An alkaloid, a glucoside, and a volatile acid have been indefinitely reported. It is a curious fact that the toxic properties are imparted alike to alcohol or hot or cold water, or to the atmosphere by burning. The death of insects by contact with the fine powder is only partly mechanical, for Jelliffe has shown that while the stem powder is thus fatal to some, it does not affect others, which, however, are promptly killed by contact with the powder of the flowers. Insect powder does not affect the insect's eggs.

Although this substance is somewhat irritating, its tincture sometimes even causing vesication of the skin, yet its medicinal action is of no importance, and its one use is for the destruction of insect vermin. Here it has the great advantage over nearly all similar agents of being non-poisonous. It not only destroys such domestic pests as roaches, flies, bedbugs, and fleas, but is very useful as applied to insect-infected plants, either in the house or in the field. For the latter purposes it is best sprayed in the form of a decoction. Mosquitos may be destroyed in a closed room by slowly burning a half-ounce or an ounce of the powder.

Henry H. Rusby.

Insects, Parasitic.—The group of insects as formerly understood included four subclasses: the *Malacopoda*, or *Onychophora* consisting of a few worm-like forms (*Peripatus*); the *Myriopoda*, centipedes and millipedes; the *Arachnida*, spiders, mites, and ticks; and the *Hexapoda*, or six-footed winged division. While these groups all agree in having jointed bodies with jointed appendages and breathing by means of tracheæ, there is so much divergence in other respects that they are now separated into distinct classes and the *Arachnida* especially considered as widely different.

The Insecta proper, or Hexapoda, are bilaterally symmetrical animals having jointed bodies with jointed appendages, the body consisting of three distinct regions, the head, thorax, and abdomen, the former of which bears jointed antennæ and variously modified mouth parts; the thorax (consisting of three segments, pro-, meso-, and meta-) bears on each segment a pair of legs and on the meso- and metathorax each a pair of wings. Respiration is provided for by means of tracheal tubes which ramify throughout the tissues, carrying air to all parts of the body. Exceptional forms, especially among the parasitic species, occur in which the wings may be aborted or entirely wanting or in which different organs may be more or less aborted. It rarely happens, however, that these reductions go so far but that the insect structure may be recognized at least during some brief period in the life history of the species.

Of the sixteen to nineteen orders which are recognized by different authors, but four include groups which are parasitic on man or the domestic animals with which he is most closely associated. These orders are the *Diptera* or two-winged flies, mosquitos, etc.; the *Siphonaptera* or fleas; the *Hemiptera* or bugs, lice, etc., and the *Mallophaga* or bird-lice.

Of the other orders there are quite a number that may have an incidental importance, as the stinging *Hymenoptera* to be mentioned under *Insects, Poisonous;* the beetles, *Coleoptera*, some of which produce vesicating properties and others which at times cause trouble by getting into eyes or ears, and the *Lepidoptera*, many of which have larvæ that have nettling properties. To give mere mention to all of these phases would outrun the limits of this article, and our further attention therefore will be directed to such orders as include parasitic, or at least, semi-parasitic, habits and affect the human species.

Diptera.—Two-winged insects, flies, mosquitos, gnats, etc. Mouth parts fitted for piercing or sucking;

a pair of mesothoracic wings and a pair of modified structures, halteres, or balancers, occupying the position of the metathoracic wings. Many of the members of this order affect man, but in such manner that it is often difficult to decide just where they should be placed. The mosquito, for instance, sucks the blood of man and might be counted semi-parasitic, but its bite is poisonous and so it may properly be included under the section of poisonous insects, where discussion of its habits in this connection is given. It has further a most important relation as the medium for transmission of certain diseases. The gadflies or horseflies seem on the whole to be better treated in connection with the poisonous insects and are so placed. Some other forms cause extreme annoyance by getting into the eyes, nostrils, and ears, causing intense irritation and sometimes requiring medical attention. The Hippelates flies, described by Dr. Schwarz from occurrences in Florida, are among the worst of these, and aside from the great annoyance and suffering may induce severe inflammation, and moreover are a menace as possible carriers of diseases of the eye or disorders of the skin.

Œstridæ or bot-flies comprise a well-marked family distinguished by heavy body, generally hairy, and with small eyes at the sides of the head. The antennæ are sunken into deep pits on the front; the mouth parts are rudimentary, and no food is taken in the adult stage.

The larvæ, which are the parasitic stage, are fleshy grubs and occur in different regions of the body of the host, such as the alimentary canal (horse bot), the nasal passages (sheep bot), the subcutaneous tissue (*Hypoderma* of cattle and, accidentally, in man, and the *Dermatobia* in man). Eggs are deposited on the body or attached to the hairs of the host to be, and newly hatched young reach the cavities they infest by

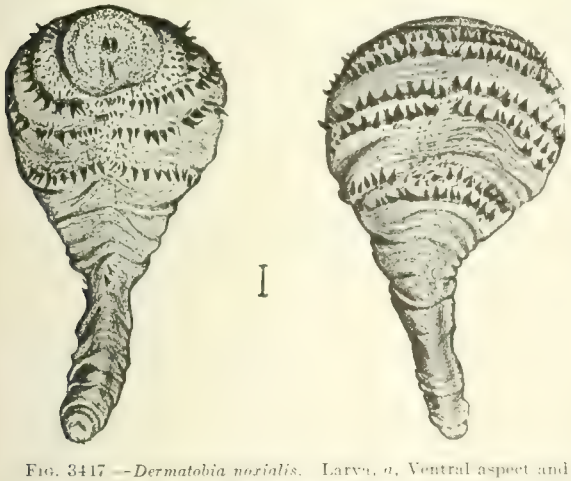

Fig. 3417.—*Dermatobia noxialis*. Larva, *a*, Ventral aspect and appearance of cephalic and caudal extremities, also the three rows of spines, single below and the point where the double rows end; *b*, dorsal view shows that the three rows of spines, single below, are double above. Greatly enlarged. (From *Insect Life*.)

various routes for the different species. While no species is to be regarded as strictly a human parasite, the occurrence of bots in man is of sufficient frequency to require mention here and consideration of the conditions under which they may infest the human species or become subjects for the practitioner.

Instances of the occurrence of the ox warble, *Hypoderma bovis*, and *H. lineata* in man have been recorded in both Europe and America. The former is the common species in Europe and its occurrence in man is noted as fairly common in Norway. The latter, which is the species occurring most commonly in America, has but few recorded instances, one of the best authenticated being that mentioned by Dr. John Hamilton (*Ent. Nov.*, iv., p. 219). Their presence will be recognized from the swollen ulcers at different points under the skin, and there is a strong tendency for them to migrate from place to place, though in the case reported by Dr. Hamilton, which ended fatally, the location was in an ulcer at the root of the tongue.

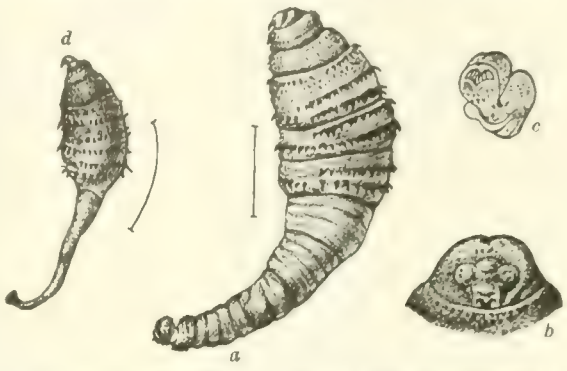

Fig. 3418.—*Dermatobia*. *a*, Brauer's figure of a larva, and *d*, Coquerel's figure of one probably identical with *noxialis*, differences due to maturity or to amount of contraction at time of preservation; *b*, cephalic extremity; *c*, caudal extremity of *a*, enlarged; lines show actual length. (From *Insect Life*.)

Œstrus hominis L. = *Dermatobia noxialis* Goudot. This, the species which has been termed the bot-fly of man, is of frequent occurrence in tropical America where it is a pest to cattle, as well as to dogs, monkeys, and other mammals; its occurrence on man being occasional, perhaps accidental, as a result of deposition of eggs on the bodies of persons exposed, as when bathing, or the exposed parts of the bodies of natives.

The insect has a variety of names in different countries: *Ver macaque* in Cayenne and Mexico, *Ura* in Brazil (Para), *Torcel* in Costa Rica, and *Gusano peludo* or *Muche* in Columbia.

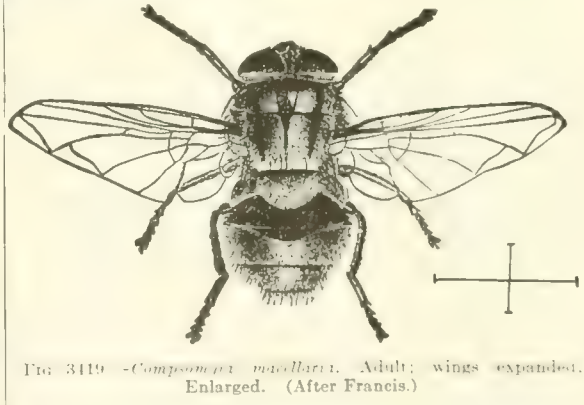

Fig. 3419.—*Compsomyia macellaria*. Adult; wings expanded. Enlarged. (After Francis.)

The larvæ are very characteristic in shape as shown in the figure, the head end being broad and the terminal segments much attenuated.

If undisturbed they complete their growth in the subcutaneous tissue, and then come out to enter the ground and pass the remaining stages of development, issuing later as adult flies. In man they are probably as a rule extracted before they acquire maturity, since they could scarcely escape notice, and even crude surgery is sufficient for their extraction.

The larvæ are to be separated from the related *Cuterebra* by the minute spines on segments two and three, and the absence of hooks on the posterior borders of segments four to seven.

Dermatobia cyaniventris with similar habits has been separated from *noxialis* by Blanchard, the larva being said to have no fine spines on segments two and three, and a row of strong hooks projecting from the hind border of segments four to seven and sometimes eight.

Muscidæ. Thick-bodied hairy flies, with well-developed mouth parts, either fitted for piercing or, as in the house-fly with soft membranous proboscis, adapted to liquid food. Larvæ, fleshy footless grubs or maggots, living in decaying matter, ordure, etc. The group is a large one, many of which, though not strictly parasitic, may seriously affect man. The

Fig. 3420.—*Compsomyia macellaria.* Adult; wings at rest. Enlarged. (After Francis.)

common house-fly, for example, aside from being a great annoyance, is undoubtedly a menace to health, since it may readily visit first the feces of a typhoid patient and then the food of table or camp. Much of the typhoid occurring in the camps during the Spanish-American war was attributed to this means of transmissal, and this with dysentery, tuberculosis, and a number of other serious diseases are now recognized as transmissible by this fly. Patients in hospitals may serve as centers of infection for ophthalmia and other diseases in adjacent dwellings, unless care is taken rigidly to exclude flies by means of close-fitting screens. It is also asserted that they may transmit the eggs of nematode and cestode worms. A number of the species which ordinarily deposit

Fig. 3421.—*Compsomyia macellaria.* Egg and egg mass greatly enlarged. (After Francis.)

their eggs in decaying organic matter may on occasion deposit them in wounds and cause very serious results. The flesh-fly (*Sarcophaga carnaria*), meat-fly (*Calliphora vomitoria*), blue-bottle fly (*Lucilia cæsar*), and others, are injurious in this way.

Compsomyia macellaria, the *Lucilia hominivorus* of early writers, the much-dreaded "screw worm" of the warmer portions of America, is undoubtedly one of the most important species that directly affect the human species and has received considerable notice in medical journals. The head is red-brown; the thorax and abdomen are bluish-green with metallic reflections, and there are three longitudinal black stripes on the thorax. It is known all the way from Canada to Patagonia and has received a great number of technical names. The eggs are deposited on various decomposing substances, but not rarely in the nostrils of individuals when sleeping, or even when awake if exposed, but probably attracted as a rule by a catarrhal condition of the person. Eggs are small, cylindrical, white, with a ridge along one side. They hatch very soon after deposition so that the opportunity for removing them is very short. The larvæ on hatching work into the surrounding tissue, and the result of their burrowing is to destroy all the tissues of the soft palate, and cases are on record in which the vertebræ and os hyoides and other bones have been completely laid bare, such cases usually terminating fatally.

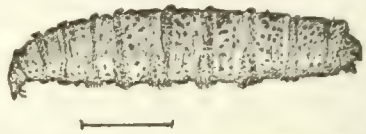

Fig. 3422.—*Compsomyia macellaria.* Larva enlarged. (After Francis.)

As many as 300 maggots have been dislodged from the mouth and nose of an affected individual, and considering the rapid growth of such larvæ, it is not to be wondered at that the tissues are destroyed with great rapidity. Prompt attention is therefore the most essential element in treatment, and irrigation with dilute solutions of phenol, of clove oil, with warm water, or with chloral, carefully used, are recommended. Pyrethrum is stated to be a certain remedy in all cases in which the maggots can be reached with it.

Order Siphonaptera—wings absent; sides with horny plates; body much compressed; the legs long and stout, the coxæ being remarkably developed; thoracic segments distinct; mouth parts fitted for suction, all the species in the adult stage feeding upon the food of mammals or birds. Antennæ small, sunken in bits or grooves in the side of the head, of modified shapes, sometimes annulated and in other cases divided into leaf-like plates. Eyes simple or often reduced to mere rudiments or apparently wanting. Tarsi five-jointed.

Fig. 3423.—*Compsomyia macellaria.* Puparia, entire at left and broken at right showing where fly has escaped. Enlarged. (After Francis.)

They undergo complete metamorphosis, the larvæ being slender, worm-like, active creatures, feeding in the litter of dog kennels or other waste material where they may get access to dried blood or animal matter; the pupæ are quiescent, and the adults seek and live more or less constantly on the bodies of the host animal. Development proceeds rapidly in warm weather, the egg stage lasting about six days, the larval period a few days, and the pupa stage a week or more. Observations on some of the species shows that the entire life cycle from egg to adult may be passed in a fortnight.

Three families are now recognized, the *Sarcopsyllidæ*, *Vermipsyllidæ*, and *Pulicidæ*, the first and last including species affecting man.

Sarcopsyllidæ. Small forms with large heads, the gravid females confined to the host animal usually becoming embedded in the tissues.

Sarcopsylla penetrans Linn., the "jigger," "jigger flea," "chigoe," and "chique." Head angular; hind angles of the metathoracic scales rounded; eyes

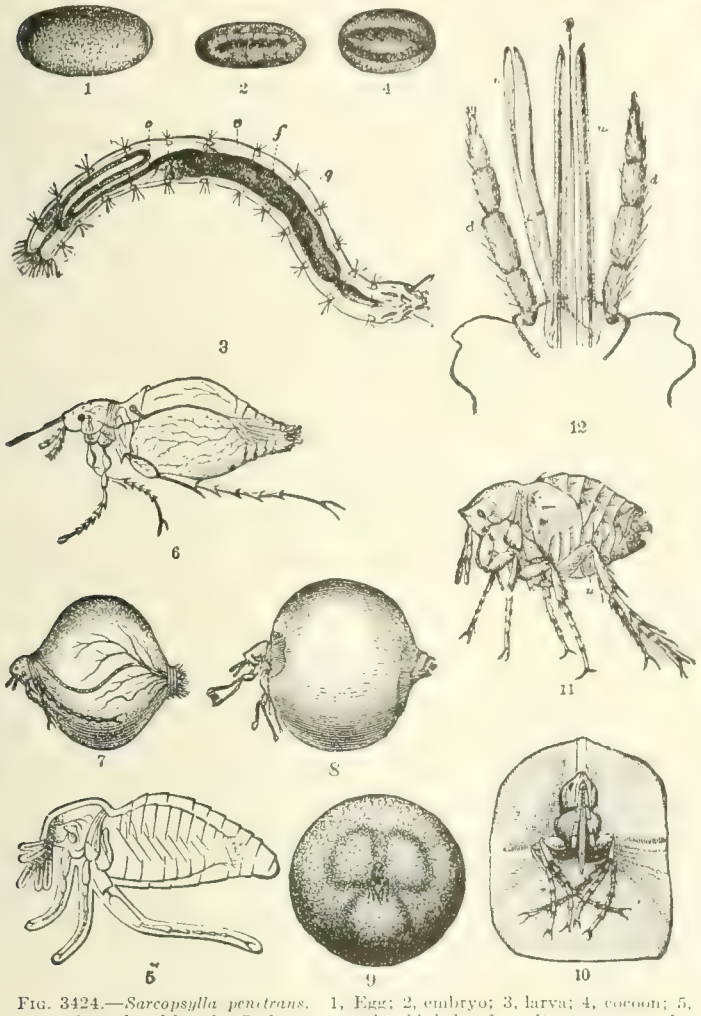

FIG. 3424.—*Sarcopsylla penetrans*. 1, Egg; 2, embryo; 3, larva; 4, cocoon; 5, pupa; 6, fecundated female; 7, the same on the third day from its entrance under the skin of its human host; 8, the same after several days' residence in the skin of its host; 9, anterior view of fully grown female, × 4; 10, head of same still more enlarged; 11, female before entering the skin; 12, mouth parts much enlarged; *m*, mandibles; *d*, maxillary palpi; *u*, labium. (After Karsten and Guyon.)

and antennæ in anterior part of head. The males and females are similar and flea-like, but when gorged with eggs the females lose all semblance to their original form.

The species has been noted particularly as a pest of man, but it is a very serious parasite of many other animals also. It appears to have been a native of tropical America, but has been carried to other countries and especially in Africa is said to have spread with astonishing rapidity.

The adults attack animals as in other species, but the females after being impregnated burrow into the skin, especially beneath the toenails in man, and there produce a swelling and later a distinct ulcer, which in some cases results fatally. The development of the eggs greatly distends the body of the insect so as markedly to change its form, the head and legs appearing as little appendages on a large round body as big as a pea. Each female is said to produce about sixty eggs, which are deposited in a sort of sac, and the young hatch and feed upon the swollen body of their mother until they are full grown, when they escape to the ground. Removal of the parasite is accomplished by the introduction of a sharp knife point, the object being to extract the insect entire as the bursting of its skin and discharge of its contents in the tissues are likely to produce distressing sores.

FIG. 3426.—*Pulex irritans*. Head and pronotum, showing form and absence of combs. Author's illustration, Bull. United States Dept. Ag.

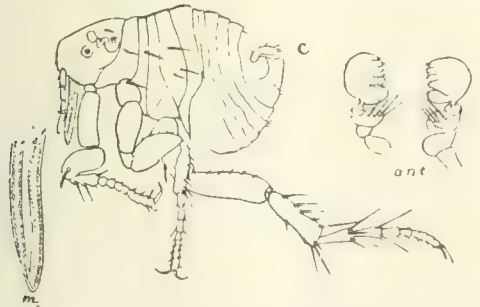

FIG. 3425.—*Sarcopsylla gallinacea*. Male. Enlarged, *ant*, antennæ; *m*, palpi, more enlarged. (From *Insect Life*, drawn by Packard.)

Sarcopsylla gallinacea Westw., hen flea. Head obtusely pointed in front; the antennæ and eyes are in the posterior half of the head; the metathoracic scales angled behind, 1 to 1.5 mm. long. This species appears to have been introduced into the Southern States probably from the Old World, and it has been observed in Florida, Mississippi, Texas, and Oklahoma, and is likely to spread over the warmer part of the country at least. Its main attack is upon domestic fowls, but it is stated to attack man, especially children. The females bury themselves in the skin, as those of the preceding species, and the sores produced are of a similar character. The effects upon the young chickens and puppies are said to be very serious and the results often fatal. But little has been ascertained regarding the affects on the human species.

Pulicidæ.—Labial palpi three- to five-jointed. The abdomen of the female does not become especially swollen with the development of the eggs.

Pulex irritans L., the house flea, is recognized by the absence of combs of spines on the border of the head and pronotum, and the length of the hypopharynx and mandibles which reach more than halfway on the fore coxæ, the single row of bristles on the abdominal segments, the large male claspers, and the dark reddish or piceous color. It has a very wide distribution over the world, and has been a familiar if not welcome guest in dwellings from remote antiquity

The attacks for blood sucking are made more particularly at night, but fleas have none of the secretive habit of the bedbug, depending on their agility and enormous leaps to escape from capture. Eggs are deposited in out-of-the-way places, in cracks and under carpets where the young may secure a supply of organic matter of various sorts to serve them as a food supply. Each female is supposed to deposit from eight to twelve eggs, which are whitish ovoid, less than a millimeter in length, which hatch in the course of from four to six days in summer, and reach the pupa stage in about eleven days, from which they issue as adults about twelve days later. The full life cycle may therefore be completed in the course of a month in summer and six weeks in winter. Preventive measures must be directed against the harbors for the development of the young, cleanliness in regard to the places where the eggs might hatch and the young develop being more effective than attention to other points, though the use of pyrethrum may be resorted to to destroy the adults.

Pulex serraticeps Gerv., the dog flea, recognized by the distinct comb of spines on the lower border of the head and on the hind border of the pronotum as shown in the figure, is in this country a more frequent pest

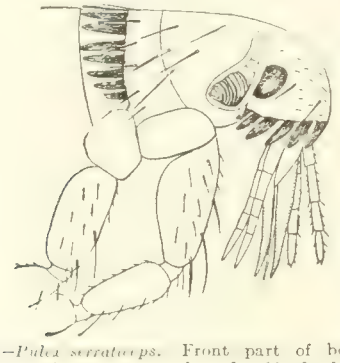

FIG. 3427.—*Pulex serraticeps*. Front part of body showing combs on head and pronotum, enlarged. (Author's illustration, Bull. United States Dep. Ag.)

in houses than the *irritans*. Its normal hosts are the dog and cat, but it seems thoroughly at home on the human species and is an extremely annoying pest. Eggs are attached to the hairs of the dog or cat, but so loosely that they drop off easily and are scattered wherever these animals may chance to rest. Both of these species are more annoying than dangerous, their bites seldom causing more than temporary inconvenience; but it is easily conceivable that they might become the carriers of the germs of infectious disease or of septic matter, and thereby assume a very different rôle.

Pulex cheopus, a common old world species and primarily a parasite of the rat or other rodents, is found to be a carrier of bubonic plague, and the present mode of control for this disease rests largely upon the extermination of rats or other small rodents which may serve to harbor the transmitting species. Other species of fleas may be concerned in this transmission, but this one is the most positively and generally associated with the disease.

Fleas have also been suspected of being the carriers of leprosy and possibly of other infectious diseases and even though this association has not been positively established there is sufficient possibility to warrant efforts of extermination for all species that affect man or animals that are commonly associated with him.

Order HEMIPTERA—insects with suctorial mouth parts; four wings, unless aborted or rudimentary, the upper or front pair being thickened at their bases. The young hatch in the form of the adults.

Cimicidæ, wings aborted or if present with simple membrane; the parasitic or semiparasitic bedbug having mere rudiments of wings.

Cimex lectularius, bedbug. Known in different localities, as chinches, chintzes, redcoats, mahogany flats, etc. It has infested human habitations since the dawn of history and is distributed over practically the whole world even into northern regions. The body is very thin and flat, oval in outline, the head sunken in the prothorax, the margins of which are finely ciliate. The antennæ are slender, the three distal joints about equal in length and covered with fine

FIG. 3428.—*Cimex lectularius*. Head and prothorax much enlarged. (Author's illustration, Bull. United States Dep. Ag.)

hairs. The wing pads are very small and never known to become fully developed. The color is light yellowish to dark reddish-brown, depending on age and the contents of the body. It has a very characteristic odor similar to that of the chinch bug and many of the other species of this order. The odor would seem to be of no advantage to the bug under present conditions and may be looked upon as a survival. The habits are nocturnal, the insect sucking the blood of man at night, and secreting itself during the day-time in cracks of furniture or walls. Its bite is in some degree poisonous, affecting some persons much more seriously than others, but is apparently due to irritation of puncture or simply the juices of the mouth, as no poison glands have been detected. The relation of bedbugs to

FIG. 3429.—*Cimex lectularius*. *a*, Young. Both enlarged. (From Riley, United States Dep. Ag.)

diseases while not fully demonstrated for any particular diseases is indicated in a number of places and they may be looked upon with distinct suspicion in this connection. Individuals hibernate or, where warm enough and conditions favor, reproduction may proceed throughout most of the year, but is most rapid in warm weather. A period of seven to ten weeks or more is occupied from egg to adult, but varies greatly depending on temperature and food. They may survive long periods without food, but development is retarded. Irritation of the bites may in extreme cases require the attention of the physician, but

ordinarily effort should be directed toward prevention. In well-kept homes the extermination is a matter of persistent use of well-known household measures, but in hospitals, asylums, prisons, and other institutions where large numbers of people of varied habits and history are brought together the problem may become more serious. In extreme cases fumigation of rooms or of whole buildings may be the quickest way to secure relief. An effective plan is to clear the room or rooms of all objects that would be tarnished or bleached by the process and then burn brimstone in a small dish set within a larger one so as to avoid possible fire from overflow of the burning material. Close all openings even down to the keyhole and leave the room for several hours after which it may be opened and thoroughly aired. Hydrocyanic acid gas can be used with best of results for these and other "vermin" in prisons and other buildings and in railway coaches or sleeping cars, where it is possible to vacate the structure and close it tight enough to confine the fumes.

Acanthia inodora Duges, "Coruco" or Mexican chicken bug. This species has been described as infesting poultry in Mexico and New Mexico and is also stated to be a very serious pest in houses. According to information recorded by Townsend it used "to swarm

Fig. 3430.—*Acanthia inodora*. Female. *a*, Outline of egg enlarged. (Author's illustration, Bull. United States Dep. Ag.)

in military posts to such an extent that the soldiers were ordered out and formed in two lines, one with brooms to sweep the corucos *en masse* up against an adobe wall where the other line stood ready with trowels and mud and plastered them into the wall alive."

There are other species of this genus which sometimes cause alarm by their abundance where swallows or bats congregate from the supposition that they are in this manner introduced into houses.

A. hirundinis Jenyns swarms in enormous numbers in the nests of the barn swallow, and may scatter over the building, but so far as known never enters houses or attacks other hosts than the swallows.

A. pipistrelli Jenyns preys upon the bat and swarms in places where these animals secrete themselves during the day.

A. columbarius Jenyns is recorded as infesting dovecotes in Europe, but has not been recorded so far as I know in America.

Suborder *Parasita*.—These are strictly parasitic insects, being confined to their hosts constantly and deriving all their nourishment from them. They are wingless, and the mouth parts consist of a tubular suctorial organ. There are two divisions of the group, the one including the forms which have a three-jointed beak and which are parasitic exclusively on bats, and which may be disregarded here, the other including our common lice, mention of which follows.

Fig. 3431.—Mouth parts of Louse (*Pediculus vestimenti*). *a*, *a*, The summit of the head with four bristles on each side: *b*, *b*, the chitinous band; *c*, the hind part of the lower lip; *d*, *d*, the foremost protruding part of the lower lip (the haustellum); *e*, *e*, the hooks turned outward; *f*, the inner tube of suction slightly bent and twisted; the two pairs of jaws are perceived on the outside as thin lines. (After Packard.)

Pediculidæ.—Rostrum very short, unjointed but surmounted by a circle of hooks; eyes reduced; antennæ three- to five-jointed; thorax with segments not sharply separated; legs thick; tarsi with a single strong claw usually fitting against a spur of the tibia; abdomen usually nine-jointed. The egg "nits" are attached to the hair of the host, and the young have the same form as the adults and like them cling closely to the host animal. The species are, so far as known, very closely restricted to one species of animal or at most to a few closely related species in the same genus, a fact which indicates a very perfect adaptation to a particular host and which may mean some particular adaptation of the mouth parts of each to the thickness or texture of the skin of its special host. The mouth parts in all cases must be capable of considerable extension, and the mechanism for probing into the skin so that the capillaries may be reached is quite complex. The fleshy rostrum is surmounted by a circlet of hooks which as the organ is extruded embed themselves in the skin and thus furnish a firm grasp whereby the tubular suctorial organ consisting of four delicate bristles may be gradually forced through the outer skin and down to the capillaries. This tube terminates, in *P. vestimenti* at least, in a delicate set of lobes which are supposed to act as tactile organs in feeling the way through the dermal cells. When the blood-vessels are reached a current is maintained by the pulsations of the pumping stomach. The injury which results from these infestations is the annoyance and irritation of their presence, and *phthiriasis* as a specific disease, meaning anything more than infestation or "lousiness," has been shown to be a misnomer. The ancient accounts of frightful and fatal consequences due to the presence of these parasites must be exaggerations or the lice have been charged with being the cause of diseases due to some other agent. Since none of the species affecting lower animals is known to be transmissible to man we may omit them from the discussion of particular species.

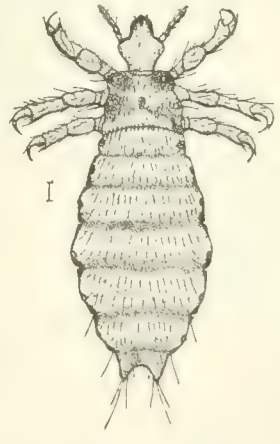

Fig. 3432.—*Pediculus capitis*. (Original.)

Pediculus capitis Degeer, head louse. Whitish with faint markings on the dorsum of thorax and abdomen and usually, in adults, distinct dark markings on the margins of the abdominal segments. The last segment of the abdomen is bilobed. This species has been recognized under one name or another during all historic time and its ancestry doubtless runs back to primitive man. While most commonly found on children it may multiply in unkempt hair of adults as well, but it seldom occurs elsewhere on the body than among the fine hair of the head. The eggs or "nits" are white and glued to the hair at some distance from the roots and are in most cases placed more abundantly behind the ears. When numerous they form quite conspicuous objects and serve as a good diagnostic feature. The newly hatched lice resemble the adults except in size, and in being less distinctly marked, and the proportions of the body vary slightly, the abdomen being smaller in proportion to the head and thorax.

Murray has shown that the different races of man harbor different varieties of this species of louse, the difference in the varieties being particularly in color and in the form of the claws. In color they differ from the nearly white infesting the Caucasian to the black infesting the African. The claws differ somewhat in proportions, and Murray thinks these differences constant.

Most cases will respond promptly to cleanly habits, but aggravated cases in asylums or poor-houses may require more heroic methods and the mercurial preparations are probably as effective as any.

Pediculus vestimenti Leach, the body louse. Like the preceding species this insect is whitish, but it has in maturity more definite markings which give it a grayish-white appearance and gained for it the name "gray-back." It is slightly larger, the head scarcely as protruding in front; the end of the abdomen not so markedly lobed or almost entire. Like the preceding species it has been a familiar object though not always recognized as a separate species. It is more common where opportunities for good sanitation are wanting, as in armies, prisons, or other places where many people are brought together under conditions that prevent due regard to cleanliness. It is said to occur on the body, most frequently on the nape of the neck, but secretes itself in the clothing when not actually engaged in sucking blood. The long slender sucking tube, by means of which it reaches the blood, is shown fully extended in Fig. 3431. The eggs are deposited in the folds of the clothing, and, according to the estimates of Leeuwenhoek, an adult female may have a progeny of five thousand in eight weeks, an estimate which he believed might be increased in the heat of summer. There is abundant basis in this estimate for all the rational accounts of excessive numbers of this parasite in certain cases. A ready means of destroying the pest is thoroughly to heat the infested clothing by boiling or by heating in an oven up to the point where both eggs and lice will be destroyed, which is considerably less than what would scorch the clothing. Fumigation may also be used.

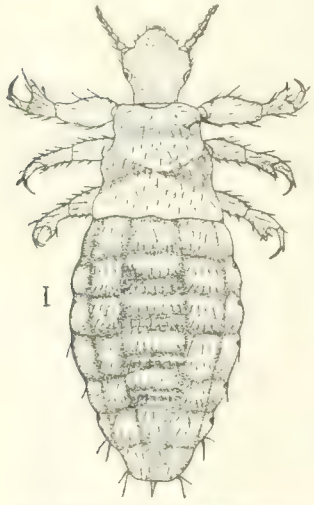

Fig. 3433 *Pediculus vestimenti.* (Original.)

Under the name *Pediculus tabescentium* Alt described the form which he considered as the cause of *phthiriasis*, but later writers have referred his observation and description to aggravated cases of *P. vestimenti.*

Phthirius inguinalis Leach. This species is very distinct from the other species occurring on man, the body being nearly as wide as long, and the spreading legs, which extend laterally far beyond the borders of the body, give it a decidedly crab-like appearance. This has given it the name of "crab-louse." It confines itself particularly to the coarse hair of the body, especially the pubic region, but may occur also on the coarse hairs of the arm pits, in the beard, and is said also to cling to the eyebrows. It is of a whitish color, with dusky patches on the thorax, the legs slightly tinged with reddish and the claw having this color more pronounced. On the borders of the abdomen there are a number of prominent lobes, and the spiracles are so arranged that three lie transversely each side at the base of the abdomen. In the female there are prominent lobes with stiff bristles meeting on the ventral side near the tip. It is nearly one-tenth of an inch (2.5 mm.) in length.

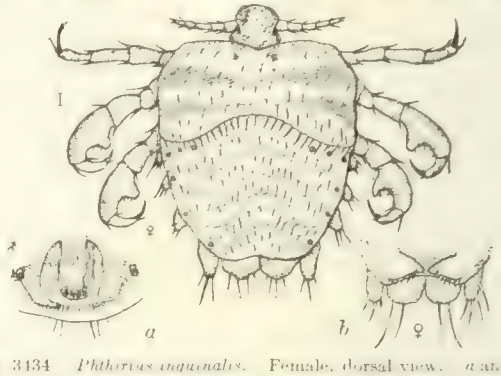

Fig. 3434 *Phthirius inguinalis.* Female, dorsal view. *a* and *b*, tip of abdomen, male and female. (Original.)

Its attacks are said to be more severe than those of the other species, and the young, by burrowing under the epidermis cause an intolerable itching. The eggs, as with other species of lice, are attached to the hairs.

Infestation may come from occupying quarters previously used by an infested person, but no person of cleanly habits is likely to be long troubled with them. For severe cases mercurial applications or stavesacre may be recommended.

The rôle that may be played by these parasites in transmitting human diseases gives them a more important place and will no doubt increase the efforts toward their extermination. While they do not migrate rapidly enough to serve as wide disseminators of specific diseases the fact that they may readily pass from one person to another and in this way introduce the germs of diseases is sufficient to emphasize their importance.

HERBERT OSBORN.

Insects, Poisonous.—As generally classified, a poisonous insect may be almost any of the *Arthropoda* that have the property of producing poisonous effects in man or in the higher animals; and it seems necessary, therefore, in this article, to refer to some forms that are not in the strict zoological sense insects or members of the group *Hexapoda.*

We may preface a discussion of the particular forms of poisonous insects by a few comparative statements regarding the organs concerned in the production of venomous material, the nature of the poison, and the means by which it is injected into the system of the victim. In all cases in which there is a true injection of venom or poisonous principle there is a develop-

ment of glands concerned in the secretion, and these glands may be variously located, depending on whether the wound is caused by the mouth parts or by a sting. The mandibles of the spider and the

Fig. 3435.—Bird Spider (*Mygale hentzii*). (From *American Entomologist.*)

solpugid, and of certain varieties of ants, as also the piercing mouth parts of the bug and mosquito (modified mandibles), are the organs of injection; and, as might be supposed, the glands connected with these organs are specialized salivary glands which have taken on the function of secreting a venomous fluid. The sting of the bee or wasp is a modified ovipositor, while the sting of the scorpion appears to be an independent structure possessing a venomous function only. In both these cases the glands are probably specialized dermal glands which, traced back, may be found homologous with the coxal glands of general distribution in more primitive groups.

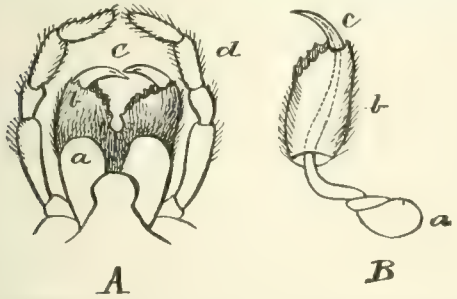

Fig. 3436. *A*, Mouth Parts of Genuine Tarantula (*Tarantula fasciventris*); *a*, palpi; *b*, mandibles; *c*, fang. *B*, Fang and poison-gland; *a*, twisted poison gland; *b*, mandibles; *c*, fang with outlet for poison. (From the Gartenlaube.)

The venomous secretion, in most cases in which it has been investigated, is of a formic acid, or similar nature. Its effect is corrosive, and the symptoms usually noted are rapid swelling and inflammation; often numbness or partial paralysis occurs; while in more extreme cases a general effect on the nervous system extending to the nerve centers is produced. The distinctly paralyzing effect on the nerve centers is especially the work of certain wasps which sting their prey in order to render it helpless and inactive, while its life is spared that the body may serve as a lasting food supply for the young hatched from eggs deposited at the time these hapless victims are captured and put in "cold storage." In the scorpion the venom affects the blood corpuscles. The effects of insect bites or stings vary greatly with the susceptibility of the victim and with the condition of the poisonous insect at the time the poison is injected. Evidently the secretion of the gland may be exhausted by prolonged activity, so that after a succession of bites or stings the effect may be slight; while the virulence is doubtless influenced also by the state of irritability or activity of the insect. Since the poison is almost invariably an acid, the general antidote is some form of alkaline base, as magnesia or lime and their carbonates, ammonia, etc.; particular antidotes are recommended further on, however, in a number of special cases.

Fig. 3437. Wolf Spider (*Phidippus tripunctatus*). (After Riley.)

Arachnida.—Among the group of spiders, scorpions, etc., known as *Arachnida*—distinguished by the presence of two body regions, four pairs of legs, a number of simple eyes, but no compound eyes or antennæ—there are certain poisonous species that shall first receive attention.

Araneidæ, Spiders.—Body of two regions, the abdomen connected by a slender pedicel; mandibles two-jointed, the outer forming a claw or fang folding against the inner. A poison gland located in the basal joint opens through a duct at or near the tip of the fang. Of this variety, the bird spiders, or

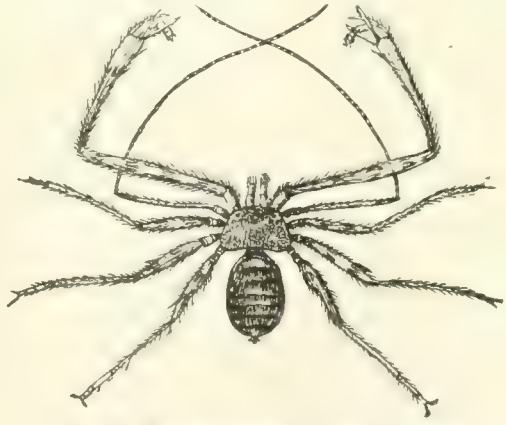

Fig. 3438.—*Phrynus lunatus*. (After Brockhaus.)

American "tarantulas" are the most formidable in appearance, some of them reaching a great size, being strong enough to capture small birds. Some of the tropical species occasionally reach Northern cities by being transported in banana bunches, and

they cause considerable interest, if not some terror, when brought to light. Their bite is quite painful, though not necessarily dangerous, being often of such a nature as to need attention. Of native species we have two: one the *Mygale hentzii*, illustrated in the figure, which occurs throughout the Southern and Eastern part of the country; the other the *Mygale rileyi* Marx, which occurs on the Pacific coast. The bite of these two species is not very serious, though in the case of children or susceptible adults the effects may be rather alarming. The true tarantula belongs to a family called the wolf spiders, *Lycosidæ*, the European *Tarantula fasciventris* being the species popularly credited with causing all sorts of afflictions, and especially the affliction known as tarantismus or tarantula dance.

Of the same family is the "malmignatte" *Latrodectus malmignatus*, inhabiting Italy, Corsica, and the Antilles. It is recorded to have appeared in great numbers in Spain on different occasions, causing much terror on account of its poisonous bite. The *Latrodectus mactans* is charged with numerous serious bites in this country, some with a fatal termination. The records are for the most part wanting in specific details, and Dr. Howard has shown that a large part of such records may be due to other causes, and especially to the bites of Piratine bugs to be mentioned late. Still another wolf spider, the *Phydippus tripunctatus* L., has been stated by Riley to produce a serious bite, and he records in the first edition of this HANDBOOK an instance observed by Dr. Otto Lugger which would seem sufficiently exact in details to require credence.

Pedipalpi.—The scorpion spiders combine the characteristics of the spider and of the true scorpion; they differ from the latter particularly in the absence of an elongated abdomen, with or without a tail but without a sting, the poisonous secretion, when present, being discharged through a fang like that of the spider. The bite of some of the species is serious, but is usually exaggerated in importance. In the genus *Phrynus* there are a number of species occurring in the southwestern part of the United States, the group being confined to the warmer parts of the globe. In *Thelyphonus*, which has an elongated whip-like appendage to the more elongate abdomen, are the whip scorpions, which, though very formidable in appearance, have, it is claimed, no serious power of biting or poisonous effect on human beings.

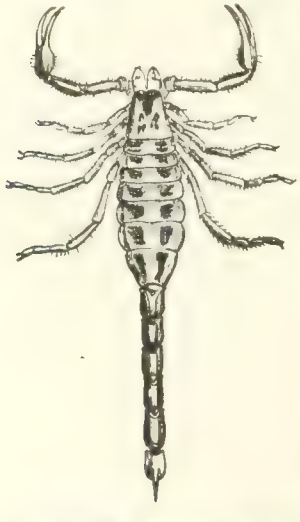

FIG. 3439.—Scorpion (*Buthus carolinus*). (From *American Entomologist.*)

Scorpionidæ.—The scorpions are a very well-marked group of animals, being recognized at once by the large chelate palpi and the slender-jointed postabdomen with its prominent up-turned sting at the tip. Two large ocelli are placed near together in the middle of the cephalothorax, and smaller lateral ocelli are arranged along the anterior margin. They are familiar objects in all tropical countries, and have always had a reputation for being dangerously poisonous, but in many cases their venomous nature has been greatly exaggerated. None of the species produces fatal or even very serious results, except it be upon very susceptible individuals. The sting is perforated at the tip, and the milky poisonous secretion is forced from the gland contained in the large bulbous telson or terminal segment of the abdomen. It is stated that the poison of the scorpion acts upon the red blood corpuscles, paralyzing them and causing them to become agglutinated, and thus to clog the capillaries and smaller blood-vessels. The symptoms are faintness, numbness, fever, tumors on the tongue, and dimness of vision. Ammonia alleviates the pain quickly, and ipecacuanha may be administered to overcome the faintness. The common species in the Southern States is *Buthus carolinus*, but a number of species occur further to the southwest and become more numerous in Mexico and Central America. Old-World species are also numerous.

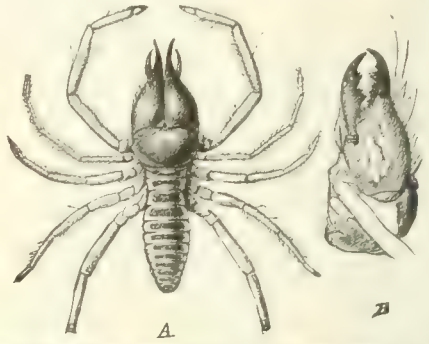

FIG. 3440.—*Butanus trivittatus* Putn. *B*, Side view of head of female. (After Putnam.)

Solifugæ (Galeodidæ).—Bodies elongate and thorax separated; the abdomen distinctly segmented. The mandibles are large and scissor-like, and the maxillary palpi leg-like. Respiration by tracheæ, and not by pulmonary sacs. These are very peculiar animals, with quite marked differences from any of the other groups of Arachnida. While they have been popularly credited with extreme poisonous properties, it is not known that they have really any serious effect on the larger animals that they may happen to bite. The mandibles are very large and strong, and they can certainly inflict a severe bite upon any of the smaller animals with which they may have to contend. They are found especially in dry regions, and in America occur in the plateau region from Colorado down to Central America, while different species are to be found all along the higher and drier portions of the American continent. In the Old World the desert or plain regions of Southern Asia and Russia are their haunts.

Myriapoda, Centipedes and Millipedes.—Bodies long, with segments of nearly uniform size and no differentiation of thorax and abdomen. One pair of antennæ, three pairs of palpi, no compound eyes but a cluster of simple eyes. The *Diplopoda* or millipedes have cylindrical bodies and very numerous legs. The species is not poisonous.

Chilopoda.—Body flattened, one pair of legs to each segment; antennæ long and many-jointed; mouth organs strong; poison glands opening in second postcephalic pair of appendages, which are strong and resemble mandibles. The centipedes, *Scolopendra*, are the most familiar species in this group, and have received much notice on account of their venomous bite, which, however, is seldom of a very serious character. Some of the species reach nearly a foot in length, but the majority of them range from four to six inches. *Scolopendra castaniceps* is the common centipede of the Southern States. It reaches a length of about six inches, and is of a yellowish-brown color with green borders to the segments.

HEXAPODA.—Insects proper. Arthropods with three pairs of legs, usually two pairs of wings; the body regions well marked into head, thorax, and abdomen. Compound and simple eyes, one pair of antennæ. This group includes an immense number of forms, and authors recognize from sixteen to nineteen orders. But few of these include poisonous forms, though they may have important relation to man in one way or another. In the suborder Homoptera of the Hemiptera, there are no strictly poisonous forms, but the Cicada, or seventeen-year locust, has been credited with a poisonous bite or sting, and this belief seems to persist among a considerable class of people.

Heteroptera. This suborder of *Hemiptera* includes the bugs with wings thickened at the base, the apical portion remaining membranous, the mouth parts appearing to rise from the anterior part of the head, which lies in a horizontal position as regards the axis of the body. Many species in this group have the ability to inflict a severe wound, and in some cases this is accompanied with an injection of saliva or some of the fluids of the mouth which produce a more or less inflamed condition, and in some instances a serious condition of the patient. The mouth parts or beak consist of a well-developed sheath formed from the specialized labium, while the mandibles and maxillæ are represented by slender setæ, the parts which are thrust into the flesh. The labium is small and scarcely noticeable. With the plunging of the slender setæ into the wound there is a discharge of fluid from salivary glands of an acid nature which acts as a poison, producing inflammation and an accelerated flow of blood. This ability is shared by a large number of the species, even many of the species that feed normally on plants being able to puncture the skin and cause a temporary inconvenience if handled carelessly. We can refer only to the more troublesome forms, and most of these are carnivorous, their natural habit being to prey upon insects.

Notonectidæ, water boatmen. Aquatic, swimming with back downward, body deep, the back boat-shaped. The rostrum is four-jointed, strong, and acute. Species of our common genus *Notonecta* give a very sharp, painful bite if handled so that they can reach the skin, and the bite is sufficiently poisonous to leave an effect for several days. They do not voluntarily attack man, so that injuries come from handling them.

Nepidæ, water scorpions. Flat, elliptical, or elongate aquatic insects with a long respiratory tube extending beyond the end of the abdomen. These probably never attack man without provocation, but they can give a severe puncture with results similar to those of the preceding species.

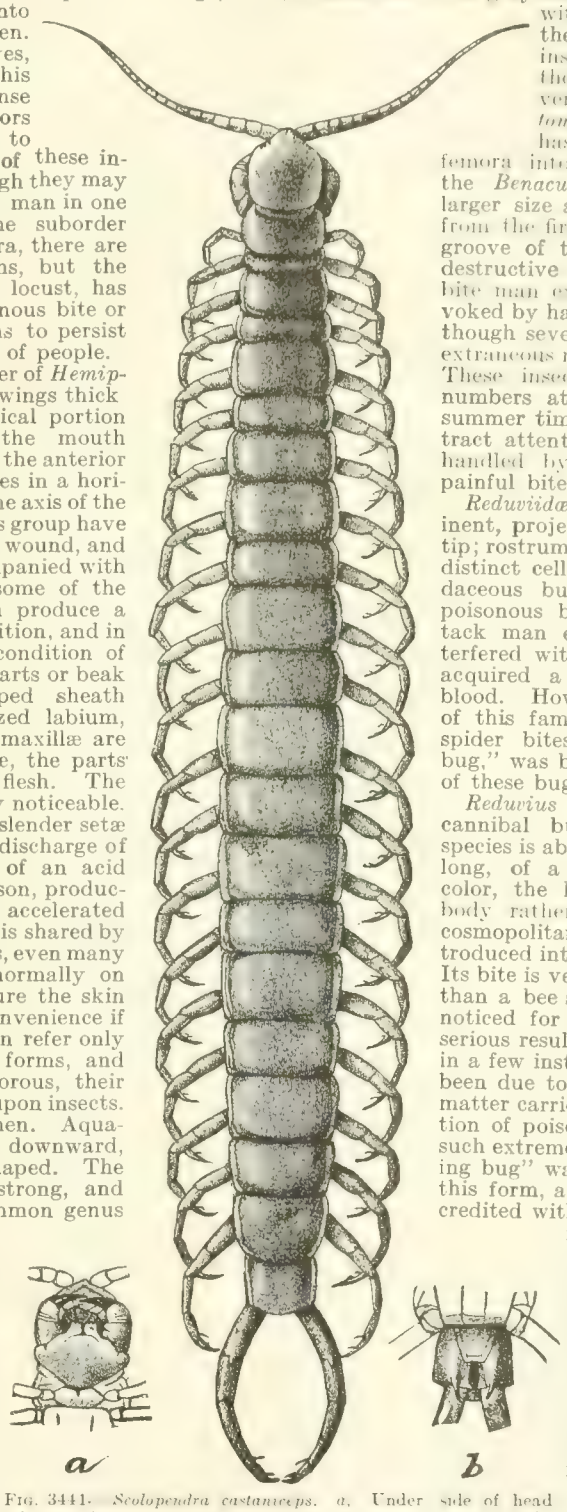

FIG. 3441. *Scolopendra castaniceps.* *a,* Under side of head showing fangs; *b,* under side of last segment. (After Wood.)

Belostomatidæ, giant water bugs. Large, flat-bodied brown or gray insects with hind legs fringed with hairs for swimming and the fore legs fitted for grasping insects or small fish upon which they prey. We have two very common species, *Belostoma americana* Leidy, which has a groove on the fore femora into which the tibiæ fit, and the *Benacus griseus* Say, of equal or larger size and scarcely distinguishable from the first except for the lack of the groove of the fore femora. Both are destructive to small fishes, and do not bite man except as they may be provoked by handling; and then their bite, though severe, is not dangerous unless extraneous matter has been introduced. These insects often appear in great numbers at electric lights during the summer time, and so are likely to attract attention and may be carelessly handled by people unaware of their painful bite.

Reduviidæ, pirate bugs. Heads prominent, projecting; antennæ tapering to tip; rostrum curved; wings usually with distinct cells. These are typically predaceous bugs, and nearly all have a poisonous bite. But few of them attack man except when handled or interfered with, but some seem to have acquired a decided taste for human blood. Howard attributes to members of this family many of the supposed spider bites, and the term "kissing bug," was based on the bites of certain of these bugs.

Reduvius (*Opsicoetus*) *personatus* L., cannibal bug; "kissing bug." This species is about three-fourths of an inch long, of a dark brown nearly black color, the head rather small and the body rather trim. It is practically cosmopolitan, doubtless having been introduced into this country from Europe. Its bite is very painful, said to be worse than a bee sting, and the effect may be noticed for several days. The very serious results which have been reported in a few instances must, however, have been due to the introduction of septic matter carried on the beak, as the secretion of poison cannot be credited with such extreme effects. The name "kissing bug" was probably first applied to this form, and it may most properly be credited with the name as it is the most frequent in houses and the only species common in the northern part of the country where some of the first cases were reported under this popular name. The species is credited with preying upon the bedbug, and its attacks on man may be interpreted, if one so chooses, as an indication of a lack of its normal food.

Melanolestes picipes, H. S., pirate bug. Black throughout, about 15 mm. long, closely resembles the following except in having the uniform black color. About equally common throughout the Northern United States, and extend-

ing south and west, occurring also in Mexico. It does not ordinarily occur in houses, but under logs and stones, where it preys upon various kinds of insects. It bites severely, but only when handled, probably never making an unprovoked attack on man.

Fig. 3442.—Point of Beak of a Hemipteron.

Melanolestes abdominalis H. Schf., pirate bug. Distinguished from the preceding by having the abdomen, at least along the border, of a bright red color. It has at times been considered as a variety, but no very satisfactory proof is available. There is very frequently a variation in the wing length or the occurrence of apterous individuals, especially among the females, as shown in the figure. The beak is powerful, and the bite, like that of the preceding species, very painful. The habits are similar, and they will be found in like situations; when caught they should be handled in such manner that they cannot thrust the beak into the flesh.

Rasahus biguttatus Say., "two-spotted Corsair." A large, strong species about three-fourths of an inch (16 mm.) long, black with reddish-brown prothorax, and a large orange-yellow round spot on the membrane of elytra. Distributed over the Southeastern United States, where it is a rather common species. Its bite is very severe, and results in severe cellulitis, the effects of which may continue for several days. No particular fear of serious effects need be entertained unless symptoms of septic poisoning appear.

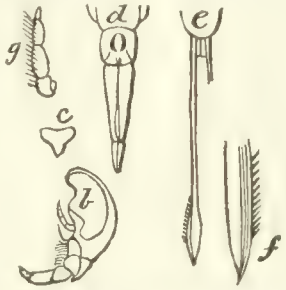

Fig. 3443.—Rostrum of *Notonecta*. *b*, Side view of rostrum. *d*, rostrum from above; *e*, one of the mandibles entire and the base of the other and of the two maxillæ; *f*, extremity of mandible more strongly magnified, with recurved teeth; *c*, labrum; *g*, antenna. (After Westwood.)

Rasahus thoracicus Stal. is a very similar species, occurring southwestward and in Mexico.

Conorhinus sanguisugus Le C., blood-sucking cone nose. Considerably flattened, the head more produced and the beak more slender than in the preceding group. The color is mainly a dark gray to blackish, with rather prominent bands on the side of the abdomen; the length is full three-fourths of an inch (16 to 17 mm.). The abdomen is broader than the thorax, and the anterior legs are not so much thickened as in the preceding forms. This species is distributed over a large range of the country from the Ohio River southward. It is called the big bedbug in some localities on account of its habit of secreting itself in beds and attacking people who may occupy them. Its bite is very severe, the beak being so strong that it may be thrust through ordinary clothing, and its length sufficient (5 mm.) to reach well into the skin. Its puncture produces violent inflammation and swelling, and is likely to fester and discharge pus for several days.

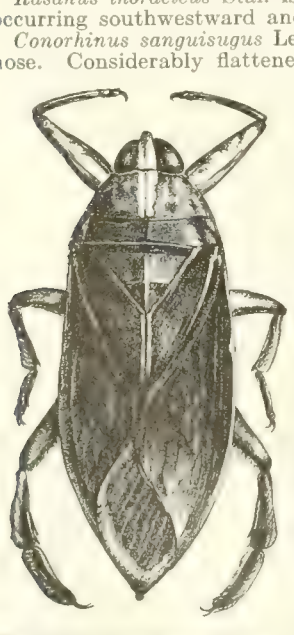

Fig. 3444.—*Belostoma americana*. (After Riley.)

Fig. 3445.

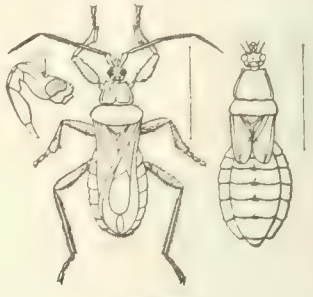

Fig. 3446

Fig. 3445.—*Reduvius personatus*. (After Howard. Bull. United States Dept. Ag.)

Fig. 3446.—*Melanolestes abdominalis*. Male at left, female at right; apterous form. Beak at left of male. (After Howard, United States Bull. Div. Ent. Dep. Ag.)

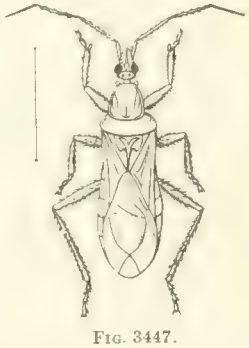

Fig. 3447.

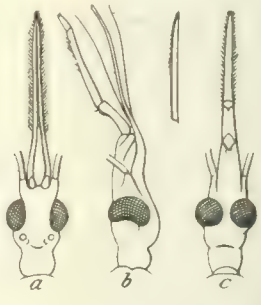

Fig. 3448.

Fig. 3447.—*Rasahus biguttatus*. (After Howard, Bull. United States Dep. Ag. Div. Ent.)

Fig. 3448.—*Conorhinus sanguisugus*. *a*, Showing beak; *b*, from side with setæ withdrawn and tip enlarged; *c*, head from below. All enlarged. (After Howard, United States Bull. Dep. Ag.)

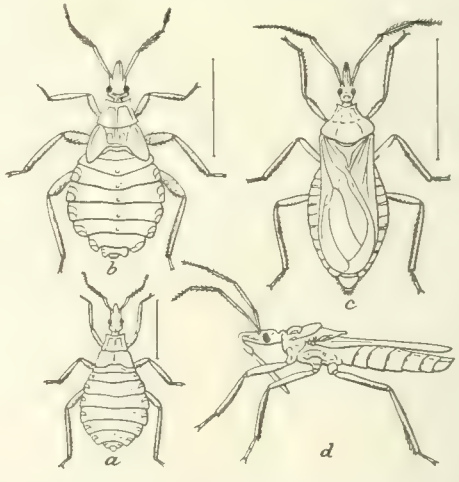

Fig. 3449.—*Conorhinus sanguisugus*. *a*, First pupal stage; *b*, second pupal stage; *c*, adult; *d*, adult lateral view. (After Marlatt, Bull. United States Dep. Ag.)

Closely related species with similar habits occur to the southwestward to the Pacific coast: *C. variegatus* Drury in the South; *C. gerstæckeri* Stal. Texas and

Western States; and *C. protractus* Uhl. in Utah and California.

Prionidus cristatus Linn., "wheel bug." A common species southward, recognized by the elevated toothed crest on the prothorax. While it does not enter houses, it inflicts a very painful bite which causes inflammation and may render the hand and arm useless for a number of days.

Many species in this family occur in tropical America and frequently prove troublesome, among them a species related to the "wheel-bug," which occurs in Chile and is called the "winhuka" or "rhinhuka." It is said to be greatly feared, and, if numerous, to drive people for a time from their dwellings.

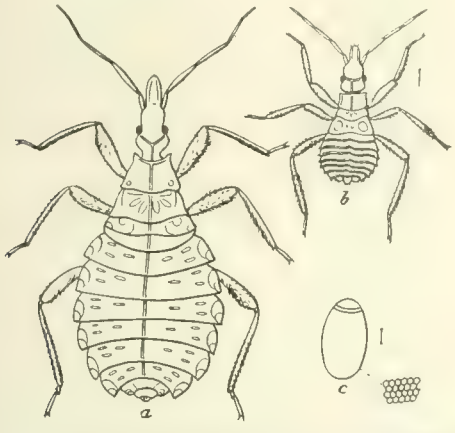

FIG. 3450.—*Conorhinus sanguisugus*. *a*, Larva second stage; *b*, newly hatched larva; *c*, egg with sculpturing at side. All enlarged. (After Marlatt, United States, Dep. Ag. Bull.)

Nabidæ.—These are small insects with considerable affinity to the preceding family, but slender and generally of dull gray or brownish color. The beak is long, rather slender, and strongly curved.

Coriscus subcoleoptratus Kby. Black or dark brown with pale legs, the body tapering anteriorly. This species is capable of inflicting a quite severe bite, and as the species is given to hiding around outhouses in wait for insect prey, and has been recorded as biting persons in privies, where there would be a rather favorable opportunity for it to introduce septic matter, its presence should be counted objectionable.

DIPTERA.—Insects with two wings, suctorial mouth parts, and complete transformations.

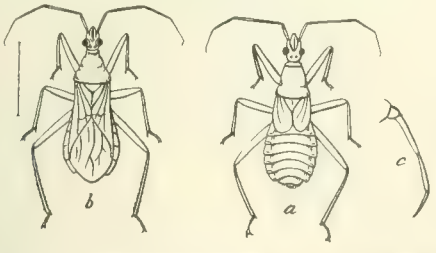

FIG. 3451.—*Coriscus subcoleoptratus*. *a*, Short-winged female; *b*, long-winged female; *c*, rostrum or beak. (After Howard, Bull. United States Dep. Ag.)

Culicidæ, Mosquitos.—Mouth parts produced into slender rostrum about half as long as entire insect, slightly thickened at tip. Antennæ slender, simple in female, plumose in the male; the veins of the wings with fine scales. The larvæ are aquatic, feeding on organic matter in the water, and rising to the surface with a jerky motion in order to secure fresh supplies of air. The pupæ are also aquatic, but with respiratory tubes opening anteriorly instead of at end of body. The metamorphosis is complete, the pupa case splitting along the back and the insect emerging above water resting its feet on the surface; the wings expand rapidly, so that the insect takes flight very quickly after the bursting of the pupa case.

The males and females differ strikingly not only in the structure of the antennæ and mouth parts, but also in habits; the latter being the ones to suck the blood of warm-blooded animals, while the former are restricted to fluids more easily accessible, and may very likely not

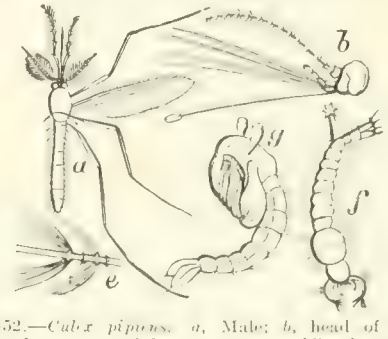

FIG. 3452.—*Culex pipiens*. *a*, Male; *b*, head of female; *e*, joints of male antennæ; *f*, larva; *g*, pupa. All enlarged. (After Westwood.)

feed at all in the adult stage. It is recorded that they sip sweets of flowers, and even such beverages as beer and wine. It is not thought essential that the females should secure blood in order to develop the eggs, but from their great efforts to secure one or more feasts of blood it would seem to be quite an advantage to them.

The secretion of a poison which is injected into the wound has been definitely proven. The poison gland is part of the salivary gland, the salivary gland of each side being divided into three lobes, the center one of which is different from the others, being evenly granulated and staining differently; and in this one the

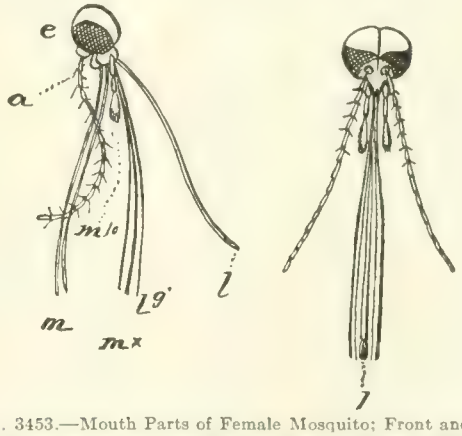

FIG. 3453.—Mouth Parts of Female Mosquito; Front and Side View. *a*, antennæ; *mx*, maxillæ; *mp*, maxillary palpi; *m*, mandible; *l*, labrum; *e*, eyes. (After Packard.)

poison is elaborated. The secretion is carried forward, and as it passes along the duct is diluted by the secretion of the salivary lobes, and the stream then passes to the reservoir at the base of the hypopharynx. The poison is injected during the process of blood-sucking, and its purpose has been thought to be for the acceleration of the blood flow or the prevention of coagulation. One suggestion is that the mosquito is primarily a plant feeder, and that the injection of this fluid serves to prevent coagulation of all proteins, and so promote suction.

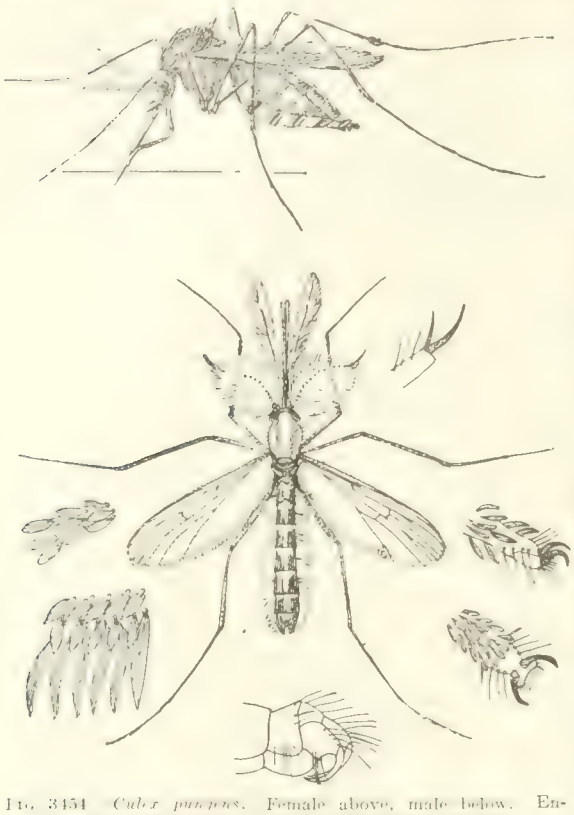

FIG. 3454.—*Culex pungens*. Female above, male below. Enlarged. After Howard, Bull. United States Dep. Ag.

The irritation varies greatly with different individuals, and some appear to acquire an immunity from the bites. Glycerin is recommended as giving speedy relief, and household ammonia applied as soon as possible after the bite is of service.

Culex pipiens is one of our most common species, and may be found in autumn and winter in hibernation in cellars and basements. Its rate of multiplication is extremely rapid during the summer months, the full life cycle being completed in the space of two weeks, so that numerous broods occur during a season. The eggs are placed in large, boat-shaped masses and the larvæ develop rapidly. Their characteristic position in getting air at the surface is shown, and may be contrasted with that of the larva of *Anopheles*.

Other species of Culex which are common in the United States are *tæniatus, tæniorhynchus, consobrinus, stimulans, excitans, impiger*, etc.

Anopheles maculipennis Meig. This species has more slender body and longer legs than *Culex pipiens;* the wings are marked with dusky patches; the scales of the last vein are black and the palpi entirely black. The eggs in this form, instead of being deposited in boat-shaped masses, are laid singly and float on the surface of water till hatched. The larvæ have a much shorter respiratory tube, and when taking air rest with the head held close to the surface as shown in the figure.

The adult mosquitos of *Anopheles* assume, when resting on wall or ceiling, positions different from those

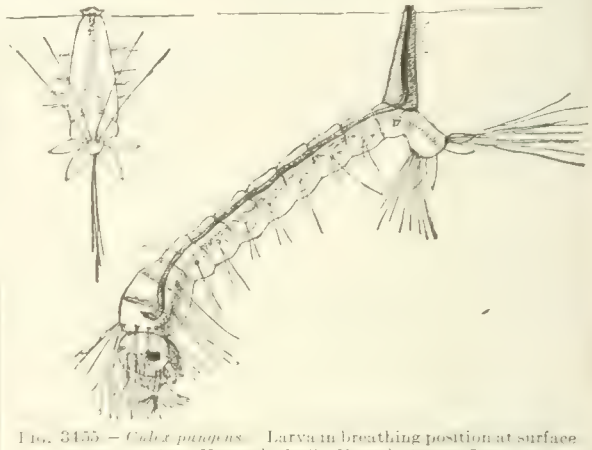

FIG. 3455.—*Culex pungens*. Larva in breathing position at surface of water. (After Howard, Bull. United States Dep. Ag.)

assumed by *Culex*, a point which may be used in separating the members of the two genera; the body is held with the proboscis, thorax, and abdomen all in one line, while in *Culex* there is a distinct bend or humpbacked appearance. Generally only four legs are used in holding to the surface, the hind pair being raised in the air; or, if the mosquito is hanging to a ceiling, they swing loose below.

Structurally *Anopheles* may be separated from *Culex*

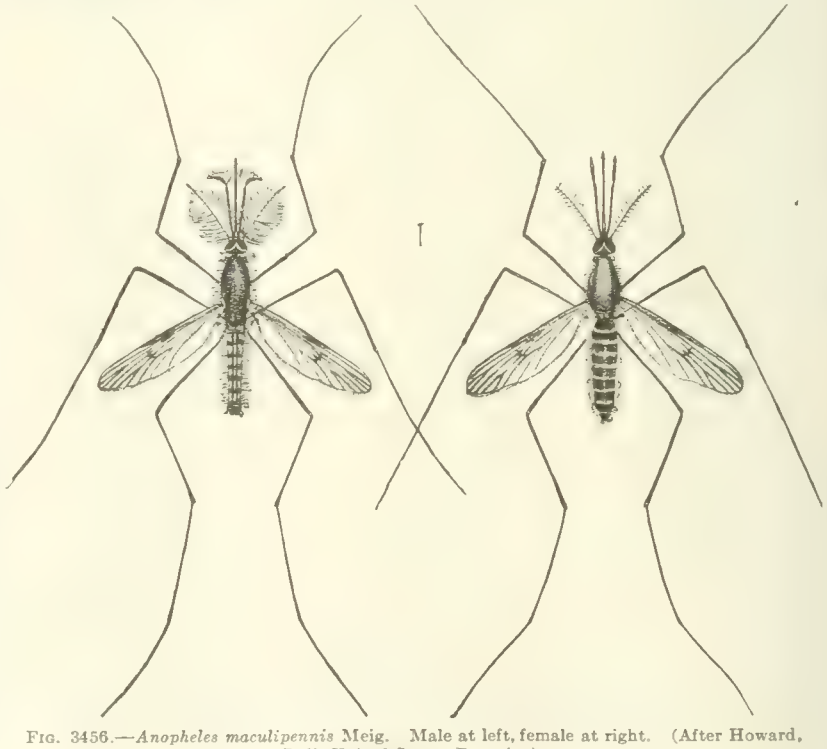

FIG. 3456.—*Anopheles maculipennis* Meig. Male at left, female at right. (After Howard, Bull. United States Dep. Ag.)

by the length of the palpi, which in both sexes are at least almost as long as the proboscis, while in *Culex* the palpi are in the female less than half as long as the proboscis, in the male nearly as long.

The species of this genus have a special interest as carriers of the malarial plasmodium.

Stegomyia fasciata, the yellow fever mosquito, has been proven to be the essential carrier for yellow fever

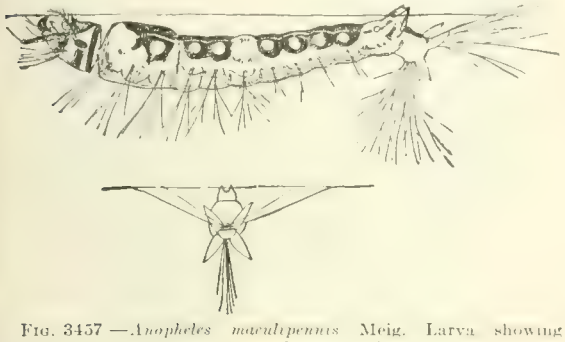

Fig. 3457.—*Anopheles maculipennis* Meig. Larva showing breathing position at surface of water. (After Howard, Bull. United States Dep. Ag.)

and the well-known results of preventing yellow fever upon this basis in Havana, Panama, and other tropical regions need not be repeated. This species is essentially an indoor species and it is safe to say, is found almost exclusively within human habitations and breeds especially in receptacles for water within or adjacent to dwellings.

Simulidæ.—Black-flies, buffalo gnats. Antennæ eleven-jointed; mouth parts fully developed, fitted for piercing; no ocelli; larvæ and pupæ aquatic; metamorphosis complete. These insects are terrible torments in different parts of the world, the most famous being the Columbacz midge of the Danube valley, the black fly of the Northeastern United States and Canada, and the Southern buffalo gnat of the Mississippi valley. Not only is their bite most painful, but a poison is injected which causes a severe swelling and produces, when many bites are aggregated, an effect of blood poisoning which is fatal to many animals; and numerous instances are recorded of serious effects on man, or even of fatalities, though these are less numerous doubtless because of the better protection which can be given to sensitive parts. The buffalo gnat, which has been studied very exhaustively by the United States Division of Entomology, illustrates very well the habits of the different species. The transmission of pellagra by these insects is still an open question.

Fig. 3458.—*Simulium invenustum*. Adult female. (After Riley, Rept. United States Dep. Ag.)

Simulium invenustum Walk. = *pecuarum* Riley. Perhaps the best known of the species and called buffalo gnat or Southern buffalo gnat. It is one of the largest species, two to four millimeters long, thorax largely blackish, abdomen of female grayish-brown or black, the sides marked with a row of velvet black spots. These gnats occur in vast swarms which in the lower Mississippi valley appear in early spring and range over a wide stretch of territory, being driven by the wind so that they may cause serious injury at long distances from their breeding grounds. Only the females have the mouth parts developed for biting, and it is said that many so gorge themselves with blood as to render themselves helpless so that they do not succeed in depositing eggs. The shade of buildings seems to be the only effective safeguard, but smudges and the application of fish oil or other repellent substances is of some advantage. The life history is quite peculiar, the larvæ being elongate, legless creatures with peculiar fan-like processes on the head end which keep up a constant motion, thus creating currents of water and bringing food materials within reach, as well as providing for the respiration. They are anchored by a silken thread and attach themselves where they get the swiftest currents in the creeks or bayous of the region where they breed. The pupæ are formed within a silken cradle-like cocoon, open at one end, from which the head portion of the pupa projects. From the anterior portion of the body projects a cluster of hair-like respiratory filaments, forty-eight combining into a trunk-like portion at the base which communicates with the tracheal system within the body. The eggs are laid close to the edge of the water on convenient objects, often where the water dashes over them so that the larvæ on hatching are carried at once into the water.

Fig. 3459.—*Simulium invenustum*. Larva (After Riley.)

Fig. 3460.—*Simulium invenustum*. Pupa. (After Riley.)

Tabanidæ.—Gad-flies, breeze-flies, or horse-flies. Mouth parts well developed, fitted for piercing; those of the females more powerful than those of the males, which latter do not attack animals. In the female there are six exserted lancet-like parts, in the male but four. Proboscis ends in two fleshy lip-like lobes and is covered on the sides by the large two-jointed maxillary palpi. The eyes are very large, especially in the males, often beautifully colored and iridescent.

There are an enormous number of species in this family distributed over the globe, and a large number occur in the United States, where they are a great torment to different animals and often to man by their severe bites. The larvæ, so far as known, are aquatic or subaquatic and carnivorous so that they are to be considered rather innoxious or even beneficial as related to man. The bites, though not strictly poisonous, are extremely annoying, and may cause such irritation as to be of importance. They are

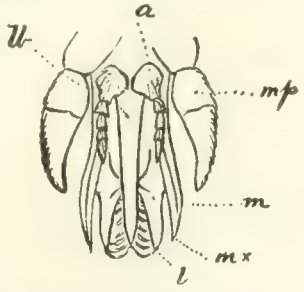

Fig. 3461.—Mouth Parts of *Tabanus*. *lb*. labrum; *m*, mandibles; *mx*, maxillæ; *mp*, maxillary palpi; *a*, basal joint of antennæ; *l*, tongue. (From *American Naturalist*.)

apt to be most troublesome in the vicinity of water, and may almost prohibit boating or bathing in certain localities. It is often stated that horses and cattle are killed by their persistent attacks, but such cases must be rather rare.

Tabanus atratus, black breeze-fly. This is one of our largest species and a very troublesome one to cattle, but it seldom attacks man or horses. It is black with a bluish-white bloom on the surface of the

FIG. 3462.—*Tabanus atratus*. *a*, Larva; *b*, pupa; *c*, imago. (After Riley.)

abdomen and the wings are a smoky brown. The larva is a large twelve-jointed, cylindrical worm, tapering at each end, of a transparent, polished, glassy, yellowish or greenish appearance, with large roundish, retractile tubercles. It is found in water or sometimes in rotten wood or among floating débris where it appears to get its food. Among other things it appears to feed commonly on mollusks.

As the horse-flies frequent pools and doubtless resort to them to drink as well as when depositing eggs it has been found that placing a little kerosene on the water serves to destroy large numbers of them and thus not only cut short their career but reduce the numbers for later generations.

Tsetse Flies (*Glossina*) which are blood-sucking African species are well known for their relation to certain diseases.

Glossina palpalis is the carrier for sleeping sickness which is due to the *Trypanosoma gambiense*.

COLEOPTERA.—Beetles. Insects in which the fore wings are hard, horny, or leathery and serving as protecting covers for the hind wings which are membranous and the organs of flight. The larvæ are various, some with well-developed legs, others footless grubs. Transformations complete.

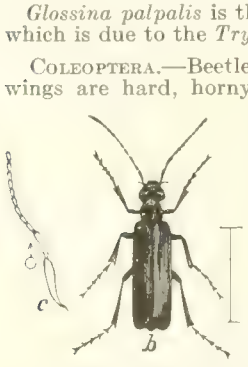

FIG. 3463.—*Macrobasis unicolor*. Line, natural size; *b*, beetle; *c*, enlarged male antenna. (After Riley.)

The ground beetles (*Carabidæ*) have in some species the power of secreting a poisonous or acrid fluid effective against small animals, but no more than repugnant to man. The Bombardier beetles discharge their secretion with a sharp report, and the cloud of vapor (which reaches some inches) has a strong pungent odor and when condensed becomes a yellowish fluid with a strong acid reaction.

The distinctly poisonous forms are included in the family *Meloidæ*, which includes our blister beetles. There are several native species which possess the vesicating property, among them the *Macrobasis unicolor*, *Epicauta vittata*, *Epicauta cinerea*, and *Epicauta pennsylvanica*. The blisters which they cause, if their vesicating fluid is inadvertently rubbed on the face or hands, may prove quite distressing, though the effect depends somewhat on the condition of the skin, being much worse if the pores are open

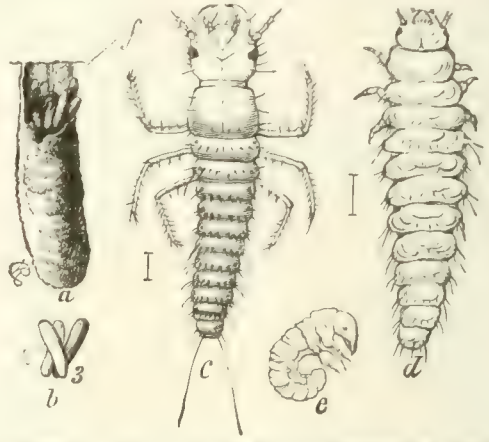

FIG. 3464.—*a*, Egg pod of *Melanoplus differentialis*, with the mouth torn open, exposing the newly hatched larva of *Epicauta vittata* eating into an egg. Natural size. *b*, Eggs of *E. vittata* the natural size indicated at side; *c*, dorsal view of first larva or triungulin of *E. vittata*; *d*, dorsal view of second larva of *E. vittata*; *e*, side view of the second larva, showing its natural position within the locust-egg mass. (After Riley.)

and perspiration is free. The early stage of these insects is very interesting and shows very strikingly that an insect that is troublesome or destructive in one stage may be very serviceable in another. Riley

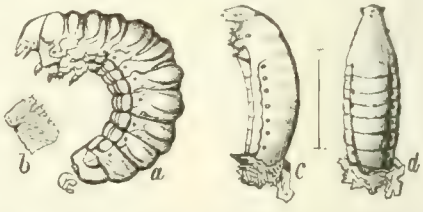

FIG. 3465.—*a*, Lateral view of the ultimate or full-grown stage of the second larva of *E. vittata*; *b*, portion of the dorsal skin showing short setaceous hairs; *c*, lateral view of the pseudo-pupa or coarctate larva of *E. vittata*, with the partially shed skin adhering behind; *d*, dorsal view of the same. (After Riley.)

has shown that the larvæ feed upon the egg masses of grass-hoppers in the ground, where the eggs are laid by the adult beetles; furthermore, that there is a distinct hypermetamorphosis. The egg hatches into a carabid-like larva with legs and active habit, and this form proceeds to search out the locust eggs and feed upon them and at its first moult changes its form to become much thicker; and after another period of feeding it moults again, changing this time to a still thicker form, the mouth parts and legs becoming atrophied. After still another period it moults again with little change except in size, and finally after another period it forsakes the egg mass and burrows into the soil to assume the pupa stage. The changes here sketched most briefly are shown very fully in the accompanying figures.

FIG. 3466.—*a*, Lateral view of true pupa of *Epicauta cinerea*; *b*, ventral view of same. (After Riley.)

Cantharis vesicatoria L., Spanish fly. This is the best known species from the medical standpoint. The insect occurs everywhere in the temperate regions

of Europe. The vesicant property is due to a peculiar volatile, crystalline chemical principle, *cantharidin*, which is very soluble in alcohol, ether, or essential oils. Externally it produces blisters and internally it is a violent irritant poison. It is said that gr. $\frac{1}{100}$ on the lip will rapidly cause a blister. Its use is mainly as a topical application in cases of indolent ulcers or as an excitant.

Mylabris cichorii, the "Telini fly" of India, possesses also very strong vesicating properties equal to or greater than those of the preceding species.

Fig. 3467.—*Automeris io*. Male moth. Natural size. (After Riley.)

Lepidoptera.—Moths and butterflies. Wings four in number and covered with minute imbricated scales, appearing as fine dust; mouth parts developed into long suctorial tube for feeding upon the nectar of flowers, though in some cases rudimentary, and the adults not feeding. A complete and striking metamorphosis, the early stages being called caterpillar and chrysalis for larva and pupa. None of these insects is poisonous in the adult stage, but a few have larvæ that possess urticating properties, or that poison or irritate the skin either from the presence of a poisonous fluid or the breaking off of minute spines. Some which are popularly supposed to be poisonous are perfectly harmless, as is the case with the large tomato worm *Phlegethontius celeus*.

Fig. 3468.—*Automeris io*. Larva. Natural size. (After Riley.)

The species which possess injurious properties belong mainly to a few families of the night-flying Lepidoptera, and include some of our very common species.

Automeris io, Io moth. A very handsome moth, the male considerably smaller than the female, brighter colored, deep yellow marked with purple brown, the body and the hind wings being of a deep ochre color; the antennæ are large, plumose. The female is darker with predominance of purple, the markings on the front wings somewhat differently arranged. The cream white eggs have a small black spot on the apical end. They are laid on leaves of various plants, the insect having a wide range of food plants, such as willow, corn, cotton, hops, clover, elm, cherry, etc. The larvæ are of a green color, and when full grown have longitudinal stripes on the sides of white and lilac red. The spines arise in clusters from papillæ and have various shapes, some with few and others with many tips. The spines are evidently connected with glands which secrete the urticating fluid, and when broken off in the skin produce an intense nettling sensation. Aside from the spines the io caterpillar possesses eversible organs on the fourth and tenth segments which probably serve to drive off some of their enemies, but they do not appear to have anything to do with the urticating property.

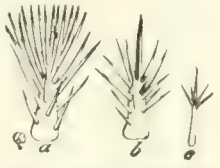

Fig. 3469.—*Automeris io*. Poisonous spines. Enlarged. (After Riley.)

Hemileuca maia Drury, buck moth. Another handsome moth the larva of which possesses urticating spines, but less severe in their action than those of the io. The larvæ are brownish black, covered with more or less conspicuous small, oval, yellow protuberances, with a lateral yellow stripe made up of papillæ and broken, irregular yellow marks.

Empretia stimulea Cl., "saddle back." A brown caterpillar with a very distinctive saddle-shaped green spot on the back. The poisonous spines are set on large processes at the anterior and posterior ends and along the sides. Here probably the poison is secreted in the larger processes and fills the small spines so that when they are broken off in the skin they cause the smarting sensation. The moth is of a rich brown color but not so striking in appearance as the larva. The larva occurs on a variety of plants, such as corn, cotton, and various trees and shrubs, but fortunately is not a very abundant species. It is also conspicuous enough to attract attention and hence less likely to be brought in contact with the hand.

Lagoa crispata opercularis Harr. is another urticating species, the poisonous spines being hidden beneath

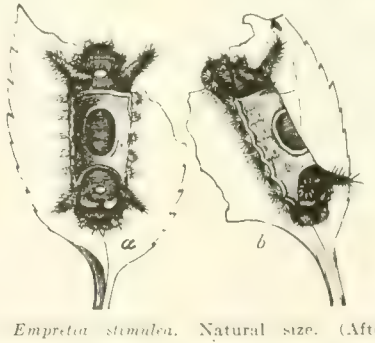

Fig. 3470.—*Empretia stimulea*. Natural size. (After Riley.)

a clothing of long hairs. In the tropics are a number of related species which are much feared by the natives.

In Europe the processionary caterpillars, *Cnethocampa processionea*, are counted objectionable on account of the urticating properties of a farinaceous substance derived from drying of an acrid secretion from the entire surface of the body. It is particularly irritating on contact and especially on delicate mucous surfaces as in the air passages. Workmen in forests where the caterpillars are plentiful are reported to sicken rapidly from this cause. "The long hairs under the microscope are seen to be branched,

and are said to be filled with formic acid. When broken off in the human skin, they produce a terrible itching and burning sensation. There are many cases on record in which such hairs have found their way by some means to the interior organs of people and animals, producing dangerous inflammation, resulting even in death." Certain Brazilian species are reported to be even more distressing in the effects produced on the human skin. Ammonia may be used to relieve the irritation.

The brown-tail moth, *Euproctis chrysorrhœa* introduced into America from Europe in the late nineties has become well established and distributed over a con-

Fig. 3471.—*Sphecius speciosa*. Giant digger. (After Riley.)

siderable extent of the New England States. The spines of the larvæ are extremely poisonous and irritating to the skin and especially detrimental if inhaled into the air passages or lungs. They seem more troublesome to certain susceptible individuals and in general should be avoided as the results may be not only extremely irritating but quite dangerous.

Hymenoptera.—Bees, wasps, ants. Four membranous wings, the hinder ones the smaller; mouth parts adapted for either biting or sucking; the body regions sharply marked; the abdomen connected to the thorax, in most forms, by a slender pedicel. This group includes very poisonous and aggressive species provided with a sharp sting, in a large portion of the group, from which a distinct poison is discharged. Even in the *Terebrantia*, in which the sting is not so specially developed, there are some species, as *Ophion* and other ichneumonids, which may pierce the skin with the ovipositor, giving a quick, sharp sting that is momentarily very painful but seldom of any lasting effect. In the *Aculeata*, or true stinging forms, there is an elaborate sting modified from the ovipositor, and hence present only in the females, through which the secretion of large poison glands is discharged. Carlet found the poison glands of the bee to consist of two kinds, one secreting a feebly alkaline fluid, and the other an acid product. The poison is effective only when the two are mixed. In those which poison with the sting both kinds of glands are well developed; while in those forms which paralyze their victims to preserve them as food for their larvæ, the alkaline glands are vestigial. In ants, wasps, and bees, there are two substances, according to Will, viz., formic acid and a bitter fatty residue, the formic acid being the essential part of the poison. In some ants the sting is wanting, but the poison glands are extraordinarily developed.

Fig. 3472.—*Chlorion cærulium*. Blue digger wasp. (After Riley.)

Formicidæ, ants. The ants usually seen are the wingless workers which are noticeable for their large heads and jaws, and their sharply separated abdomen. The males and females are winged, but the latter lose the wings after being fertilized and taking up their duties as the mother of a colony. The workers which are undeveloped females have, like the queens, a sting, and in some forms it is used with severity upon any disturber. In other species the bite is poisonous, being accompanied with an injection of formic acid. The colonies when disturbed attack the intruder with great fury, and some of the larger species inflict such serious wounds that death is said to result from their attacks.

Mutillidæ, "velvet ants," "cow-killers." Brightly colored ant-like insects with a dense covering of hair giving them a velvety appearance. The body is exceedingly hard, very difficult to crush, and the sting is quite severe. They occur particularly in open and sandy places and seldom sting unless caught.

Fossores, digger wasps. This group includes a large number of our common wasps, among them some of the most poisonous we have. While as a rule inclined to attend strictly to their own affairs and not to sting except on provocation, they will sometimes make unprovoked attacks. They agree in constructing nests in the ground, are mostly strong-bodied, and capture other insects or spiders with which to provision the nests for their young. The stings they inflict on these victims are directed to the nerve centers and serve to paralyze but not to kill, so that they are kept fresh but helpless till such time as the young hatch and are ready to feed upon them.

Fig. 3473.—*Pepsis formosa*. (After Riley.)

Sphecius speciosus Drury. This is one of the largest species, and a common insect in the Central and Southern States. It provisions its nests with Cicadas, which are frequently much larger than itself. Its sting is very severe, and Riley states that two or more inflicted on a man at one time might easily endanger his life. It may certainly be counted as dangerous as the scorpion and ought never to be provoked to try its power.

Chlorion cærulium Drury. A handsome blue species with dusky wings. It occurs very frequently around houses, seeking spiders which it captures, stings, and stores away in its nest for its young. Its sting, while not so severe as that of the preceding species, is by no means to be despised, and since it is a more frequent

visitor in houses it is more likely to be incited to attack.

Sphex ichneumonea L. is a large species with brilliant golden markings. It frequents flowers and captures meadow katydids to store in its nests which are placed in gravelly walks or along roadsides where the ground is very hard.

Sphex pennsylvanica L. is another common species equalling the preceding in size, but of a brilliant blue-black color.

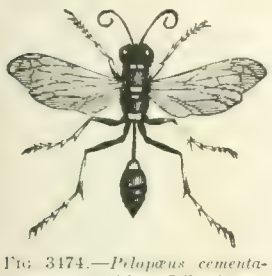

Fig. 3474.—*Pelopæus cementarius.* (After Riley.)

Pepsis formosa Say, "tarantula killer." A gigantic species, which occurs in the southwestern part of the United States, where it is counted serviceable on account of its killing tarantulas, with which it provisions its nests. Its sting is very poisonous.

Pelopæus cementarius Drury, "mud dauber." A dark species, with yellow lunate spots and with a very slender petiole supporting a small abdomen. This species is very frequently noticed in houses, in attics, or even in much-used rooms, where it can gain access through some crack, and in barns, sheds, and tents. Its nest is constructed from pellets of mud, and the cells each containing a larva are stored with small spiders. They seldom molest people, even when passing very near them to reach the nest, but sting severely if provoked, and their presence is in itself annoying on account of the fear. There are many related species, some of which also build nests in houses.

Fig. 3475.—*Vespa maculata.* (After Riley.)

Vespidæ, paper wasps. Wings folding longitudinally when at rest; bodies rather robust, the abdomen attached by a short pedicel. All the species sting viciously when disturbed, and do not always wait for any serious provocation. Two species may serve as examples of the group.

Vespa maculata L., bald-faced hornet. A heavy-bodied species with light yellow, almost white face, and yellow spots on the thorax and abdomen. The large nest is built by degrees of a strong gray paper and

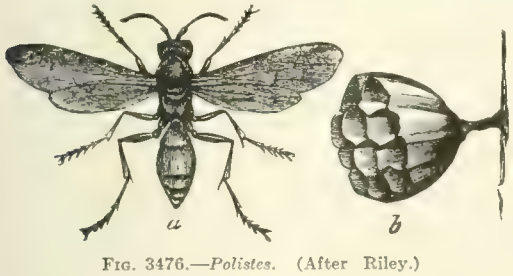

Fig. 3476.—*Polistes.* (After Riley.)

contains, when fully formed, a number of combs one above another all enclosed within the large outer case. The opening is at the lowest point and the whole nest is hung by a stout cord to a branch of a tree or the under side of a fence rail or other suitable support. If disturbed these hornets make a fierce attack on the intruder and a number of stings will cause pretty serious symptoms in the victim. Applications of ammonia, glycerin, bicarbonate of soda if made promptly will much relieve the swelling and inflammation.

The "yellow jackets," *Vespa vulgaris* L. and *V. germanica* F., are smaller, but similar in habit, and fully as vicious.

Polistes pallipes St. Farg. The more slender species included here also build paper nests, but only a single comb and this without any outer case; so the growing larvæ may be easily seen by any one with sufficient nerve carefully to inspect the nest. They are frequently built in houses in window frames and the wasps may become troublesome as the number increases and they grow irritable.

Apidæ, bees. Robust, usually hairy, the mouth parts with a long tongue adapted to lapping the nectar from flowers. This family includes the bumble bees and the honey bee as well as a large number of species less familiar. The sting is like that of the other *Aculeata*, and that of the honey bee may be noted as an example of the others. The principal parts are the three pieces of the normal ovipositor, the center one of which constitutes a sharp lancet-like instrument. At its base is the large poison reservoir fed by the poison gland.

Fig. 3477.—Sting of Bee. Enlarged. *a*, Tip of lancet, still more enlarged. (After Gosse.)

Xylocopa virginica Drury, "carpenter bee." This species very much resembles a bumble bee, but has the abdomen polished and without hair. They bore into wood to construct nests and so may prove troublesome around houses, as their sting is very painful.

Bombus sps. The common bumble bees are very familiar objects, several different species occurring in almost any locality. They build nests in holes in the ground or, rarely, in deserted bird nests or other places at some distance above ground.

Apis mellifica, honey bee. The domesticated bee is now represented by several varieties. They are the most frequent source of stings since they are so commonly kept in the vicinity of houses. The sting affects different persons very differently, some suffering intensely from a single sting, while others suffer no inconvenience, after the temporary pain, from a number of stings. Inflammation, rapidly extending from a sting on the hand even so far as the length of the arm, and sometimes so as to close the eyes, may follow. Prompt application of ammonia, bicarbonate of soda, or even of moist clay will serve to give relief.

HERBERT OSBORN.

Insolation.—See *Heat-stroke.*

Insomnia.—See *Sleep, Disorders of.*

Instinct.—This word, etymologically meaning impulse, denotes the unreasoning impulse to perform some purposive action without an immediate consciousness of the end to which that action will lead (Stedman). This is an unusually complete definition; the only considerable characterizing feature which it omits is the consideration that the "purposive action of instinct is directed toward biologic rather than toward distinctively personal ends; and if one were to try to be precise, he would have to limit instinct to animals, the corresponding process in plants being termed taxis or tropism. Instinct is an hereditary habit. In this little article, only an outline-sketch of an important aspect of our lives, we shall limit the description to the instincts of man.

Inasmuch as in man alone the two-phased basal tendencies, impulse and its restraint, are both well developed, it is especially important for our present purpose to realize that instinct is largely of the former active nature, making for biologic activity, actuation, thrust, impulse, rather than for inhibition, its human complement. This is not wholly so, to be sure, for pure instincts, in so far as partaking neurally of actions which must be classed as voluntary, have inhibitory factors, as is the inherent nature of voluntary movement also. The beautifully skilled construction of some nests, cocoons, etc., are obvious examples of this, for while purely instinctive on one hand, neurally they are voluntary movements so far as each individual is concerned and therefore in part inhibitory and perforce cortical in innervation. To ascribe all "instinctive" actions to the lower reaches of the cerebrospinal axis in vertebrates and to the corresponding neural regions in invertebrates is to unwarrantably extend the powers of these coordinating knots of neurones. To estimate an instinct as an elaborate tropism, as does J. Loeb, or, on the other hand, as an advanced moral human motive, as is untechnically often done (conscience) in common speech, is to miss the particular domain at present ascribed to instinct in the science of behavior. At the same time, these more or less opposed attitudes emphasize anew something of fundamental importance in physiology: there is complete continuity between the most plainly sympathetic automatism and the most novel and effortful "mental" and voluntary human action. Automatisms, reflexes, habitual "voluntary" movements, (new) voluntary movements, and acts of pure choice constitute a continuum whose division into varieties of behavior is a matter only of arbitrary definition.

James has spoken of an instinct as "a tendency to act characteristically when in the presence of a certain object in the environment;" and Parmelee (in his recent "Science of Human Behavior") defines instincts as "congenital tendencies to more or less definite modes of action;" while McCabe ("The Evolution of Mind") seems to follow Lloyd Morgan and "most writers" in confining instinct to "purposive actions that are and always were wholly independent of intelligence"—"intelligence" in McCabe's unduly narrow notion of that concept. It is plain that all competent ideas of instinct, wherever they may limit its complexity, downward or upward, practically agree that an instinctive action is characteristically *mechanical*, in its nature, inherently and clearly part of the biologic, vegetative *machinery* underlying the evolution of this planet's life—an "unreasoning" impulse quite as surely as it is an activity far more complex than a tropism.

There has been, and still is, a large degree of disagreement as to just which of the numberless impulses to perform mechanically some purposive action without immediate consciousness of its purpose shall be classed as instincts and which in some other way. James, for example, taught that man has more instincts than any other animal, while Charles Darwin considers that he has fewer than any other—an opposition which suggests only how vain discussions are in general before exact definition is agreed upon. The fact appears to be that human behavior is too complex and the innervation of human instincts far too extended in the nervous system to allow of any list being made to which two or three "authorities" even would agree as exact and exhaustive. Why not be wise, then, or at least wisely conservative, and refuse to attempt the impossible, attempting to make a list of "the instincts" only when we attempt to make a list, or a classification, of odors, for example, perceptible by the human olfactory lobes, for it is certain that no two judges would agree together.

There are two *classes* of instincts, however, worth noting, especially in a treatise intended primarily for physicians. All human instincts (unlike some of the instincts of the brute) are directed apparently either toward *self-preservation or the preservation of the human race*, toward what we have already spoken of above in short as biologic ends, the furtherance of the evolutionary ends, that is, of the living, conscious, process. We have hence two classes of instincts, often in clash and perhaps as often or oftener in alliance, instincts of self-preservation, and a broad, complex set of tendencies which are part of the sexual instinct. So far as properly instinctive at all, most of the reactions of men and women and children are directed toward these two ends. It is essential that the physician should be effectively aware of the universality of these two sets of instincts in the thoroughly normal individual when not under the extraneous influence of ideas foreign to his biological nature. These two biologic interests, one way or another, immediately or remotely, selfishly and brutally or in an attenuated form so thin that their real nature is seemingly lost, dominate the lives of us all. The ascetic, apparently suffering this life through, seeks only to defend himself against loss of happiness hereafter, and the most refined and broad-minded mother of a family, the essence of womanly modesty, queen of a man and of a home which all admire, is demonstrating everywhere everyday how dependent on the sexual instinct, culminating in abundant motherhood, are the very highest phases of even our human life. When the great public learns this intimacy of relationship, this continuity between the brutal and the divine, biologic science will begin to take its proper place in popular estimation. For the physician to understand this true instinctive basis of most human motives is to more accurately estimate at their true worth, or near it, values of behavior which are often overestimated, and whose irresistable force, on the other hand, is quite as often underestimated. In short the body and its modes of action, automatic, reflex or voluntary, is the sole means known to us by which a human personality can possibly attain its apotheosis, developing thereby the sanction for its creation.

As much to show the inconsistencies of attempting to systematize things by nature unsystematic as for any instructive purpose let us run through some of the lists of human instincts (quoted by Parmelee, *loc. cit.*) prepared by relatively recent writers. James uses the term instinct in a very broad sense and includes several of what most physiologists would term reflexes: crying, sneezing, snuffling, snoring, coughing, sighing, sobbing, gagging, vomiting, hiccoughing, starting, moving the limbs when tickled, touched, or blown upon; sucking, biting, clasping, carrying an object to the mouth, smiling, turning the head aside as a gesture of rejection, holding head erect, sitting up, standing, locomotion, vocalization, etc.; imitation, emulation or rivalry, pugnacity, anger, resentment, sympathy, the hunting instinct, fear, appropriation or acquisitiveness, constructiveness, play, curiosity, sociability, shyness, secretiveness, cleanliness, modesty and shame, sexual love, jealousy, and parental love. Some of these look more like reflexes, some more like emotions, than instincts properly so-called, while of course modesty is not an instinct at all, never being congenital and seldom lacking "consciousness of the end" to which the action leads. James's list of the instincts always seemed to the present writer as the least well-considered portion of his remarkable psychologic discussion.

Angell says that the generally recognized instincts in man are the following: fear, anger, shyness, curiosity, affection, sexual love, jealousy and envy, rivalry, sociability, sympathy, modesty, play, imitation, constructiveness, secretiveness, and acquisitiveness. Angel says elsewhere in his book ("Psychology," p. 339) that instincts "represent structurally

preformed pathways in the nervous system, and stand functionally for effective inherited coordinations made in response to environmental demands." Wm. McDougall ("*Social Psychology*," III) thus lists the principal human instincts: flight, repulsion, curiosity, pugnacity, self-abasement, self-assertion (parental, reproductive, gregarious, acquisitive, and constructive).

The last-given list seems to be as satisfactory as any so far printed, for analysis shows it to be made up of processes classifiable as either self-preservative or race-preservative, curiosity being obviously a phase of "acquisitive self-assertion," the objects acquired being mental rather than material.

Kirkpatrick has made a rather useful classification of the instincts, although here as elsewhere the various portions of behavior merge into each other, and their classes likewise to some extent. There are six groups in this schema of the instincts: "1. Individualistic or Self-Preservative Instincts: Feeding; fearing; fighting. 2. Parental Instincts: Sex and courtship instincts; singing; self-exhibition; fighting for mates; nest-building (love of home). 3. Group or Social Instincts: To arrange themselves in groups; to cooperate for the common good in attack and defense; seeking companionship, desiring the approval of the group which one joins; pride; ambition; rivalry; jealousy; embarrassment; shame. 4. Adaptive Instincts: Tendency to spontaneous movement; for nervous energy to take the same course that has just been taken; to imitation; to play; to curiosity. 5. Regulative Instincts: The moral tendency to conform to law; the religious tendency to regard a higher power. 6. Resultant and Miscellaneous Instincts and Feelings: The tendency to collect objects of various kinds and to enjoy their ownership; to construct or destroy and the pleasure of being a power or cause; to express mental states to others of the species and to take pleasure in such expression; to adornment, and the making of beautiful things and the esthetic pleasure of contemplating such objects." This classification is the most scientific known to the present writer, but, as has been suggested already, its members include behavior series far outside the classic instinctive range. However, it is only a matter of definition after all, and if it becomes fashionable to so extend the denotation of the term instinct, this list is unexcelled.

On the other hand, the present tendency is to abandon such terms as instinct and imitation as relics of the old superstitions, phrenology, and "faculties" of earlier respective periods, and to attempt the more fundamental task (however forbidding in our present infinite ignorance about the nervous system) of figuring and explaining the really original tendencies of man and their neural pathways. Thus Thorndike of Columbia in his suggestive "Original Nature of Man," 1913, remarks, "If one insists resolutely on replacing a list of instincts as magic potencies which produce certain results, by a statement of even roughly definable bonds between actual situations and actual thoughts, feelings, and acts, it becomes necessary to part company with the stock descriptions of instincts." The straight road to this important goal undoubtedly lies in histological and physiological research into the precise neuronal paths of adaptive reactions, especially so far as kinesthetic; and also in a recognition that the basal contrast between pleasure (pleasantness) and pain (unpleasantness), euphoria and dysphoria, constitutes the starting-point of every efficient study of behavior. At present, ignorance of the nervous system compels a continuance of disorder in the science of habituation, instinct, intuition, and of behavior in general.

GEORGE V. N. DEARBORN.

Intelligence Tests of.—With the advent of experimental methods into psychology the measuring of intelligence became a possibility; but the possibility did not become a reality for many years, principally because the psychological experiments were carried on with adults where the problem of intelligence is enormously complicated. It was early seen that the various psychological tests when applied to adults had very little relation to intelligence. A person might have fine discrimination for lifted weights but be correspondingly weak in other mental processes, so that his total mental status would be only average or poor. His memory span might be weak but this could be made up by other excellences which would bring him up to, or above the average. Even to-day there are no methods of determining accurately the intelligence of a normal adult.

It was the genius of Alfred Binet that conceived the idea of measuring the intelligence of children during those years when the mental processes are comparatively simple and easily determined.

In 1905 Binet published a short article entitled "Apropos of the Measuring of Intelligence" (*l'Année Psychologique*, vol. xi, pp. 69–82, 1905). He alludes in this to an article published the previous year in the *Journal de Psychologie* by M. Biervliet, to whom he gives credit for having made some suggestions. The article, however, was as Binet says, only a few notes made after some experiments on the acuteness of vision and touch. In his own article Binet lays down the criterion for a test of intelligence. He says: "If one succeeds in finding a test easy to repeat and precise, which shows a development parallel with that of the intelligence, one will then have done a great service to pedagogy in furnishing a test of intelligence, a criterion with which it will be possible to judge and measure the intelligence of people." The plan is simple; its execution difficult in the extreme.

In a later article in the same volume entitled "On the Intellectual Level of Abnormals" Binet in collaboration with Dr. Simon gives us thirty such tests. These are arranged in order of difficulty. He had not at that time worked these out closely enough to tell us at what age any one test should be answered. It was not until 1908 that he gave us the complete Measuring Scale of Intelligence. This he revised in 1911 and in this scale we find our illustration of what Binet means by "A test easy to repeat, and precise, which shows a development parallel with that of the intelligence." For example, the ability to copy a square drawn on paper. Ability to copy this is absent at the age of two; it shows very slightly at three, is better at four, and rises to practical perfection at five. Beyond the age of five it presents no difficulty to the normal child. It is thus assigned by Binet to the age of five as asuitable test.

We can say, therefore, so far as this test is concerned, that if a child can copy a square he has the mentality of the average child of five years. But nothing is more common than the variability of children, and one is sure that some children could draw the square at three while others could not draw it until seven. Binet obviates this difficulty in his scale by finding five questions that are suitable for the age of five; the result of this is that if the child is precocious in drawing the square he may be a little backward in something else, and the two will offset each other, and with the use of the five questions that are set for that age, the individual variations are averaged down and while the performances of different five-year-old children will vary in the different questions, the final results will be the same for all.

It is evident that such questions as the copying of the square would not measure intelligence beyond the age of five, because the square is copied perfectly at about that time. For children of ten or of the other ages, other questions must be found which reach their perfection at a later age.

Binet's *plan* is perfect and he has worked it out with marvelous success. It is true that some of his

questions have such a wide variation that they are not as satisfactory as one could wish, and few of them are as exact as the square that we have mentioned.

There have been many theoretical objections to the scale, and the psychologists have been prompt, as Binet predicted they would be, in pointing out the imperfections and even the impossibilities of the scale.

One objection that it has been hard for the layman to get over is the belief that school training would have an enormous influence upon the results. This has come from the popular idea that a child's development depends upon his schooling and that without schooling the mind would not develop with anything like uniformity. It is largely to the Binet-Simon Scale itself that we owe our understanding that the mind does develop of itself, and that a child who has never been in school may nevertheless be intelligent in proportion to his age. In practice the scale has proved a success. An expert in its use can grade the intelligence of a child to a nicety, while even the novice can learn more about a child in a half hour than any other method would give him in weeks or even months.

These tests of intelligence cover the ages from three to twelve. Binet did indeed propose tests for ages fifteen and above fifteen, or what he termed adults, but in these he has not been so successful and they are not now in use.

The scale has been authorized for use in determining the mentality of school children by the English Board of Education. It is used in juvenile courts, has been accepted in criminal cases to show that a murderer, for example, was of such low intelligence that he came under the provision for imbeciles. It is used in a large number of school systems in many countries.

The following is an abridged translation of Binet's description of the tests. The paragraphs in brackets at the end of the description of each test indicate further details that have been adopted by the Vineland laboratory.

Children of Three Years.—1. *Where is your nose? Your eyes? Your mouth?* One of the best signs of awakening intelligence in young children is the comprehension of spoken words. We test this by asking these questions which can be answered by a gesture.

[Other parts of face are harder. Do not persist to the point of annoying the child. If necessary, because of shyness, help on the first and then if he succeeds on next two give him a fourth one. *Be sure you do not help.*]

2. *Repetition of Sentences of Six Syllables.* "It rains. I am hungry." (Six syllables.) Experiment proves that it is easier for a child to repeat words than to speak a word of his own. If a child does not respond one may try him with two syllables ("mama") then four, etc. A child of three repeats six syllables but not ten. There must not be a single error. [Give no second trial unless there was a distraction the first time. If second trial is necessary use another similar sentence, trying to follow Binet's division of syllables. Do not refuse a child credit because of defective pronunciation if he has said the whole number of syllables.]

3. *Repetition of Figures.* "6–4." A child of three can repeat two figures. Figures require closer attention than words because they mean nothing to him. Pronounce the figures distinctly, one-half second apart and without emphasis on any one figure.

[Out of three trials one must be correct. Use different number combinations each time.]

4. *Describing Pictures.** A picture is shown to the child with the question. "*What do you see?*" The pictures must be chosen with some care. Each one must represent some *people* and *a situation*. Binet uses three pictures. The first is a man and a boy drawing a cart loaded with furniture. The second, a woman and an old man sitting on a bench in a park in winter. The third a man in prison looking out of the window; a couch, chair and tables.

[Be careful of form of question. Say, "What do you see in this picture?" Use at least three pictures.]

A child of three names the things enumerates. He does not describe any actions in the pictures.

5. *Name of the Family.* All children of three know their *first* name. They sometimes know the *family name* but not always. If he gives only first name, as John, one may ask, "John what?"

Children of Four Years.—1. *Sex of Child.* "Are you a little boy or a little girl?" If testing a girl, give the question in this form. *Are you a little girl or a little boy?* Children of three do not know. Children of four always do.

2. *Naming Familiar Objects.* One takes from his pocket a *key, a knife,* and *a penny.* [Objects other than those given, may be used if examiner is sure child is familiar with them. Say, "What is this?"]

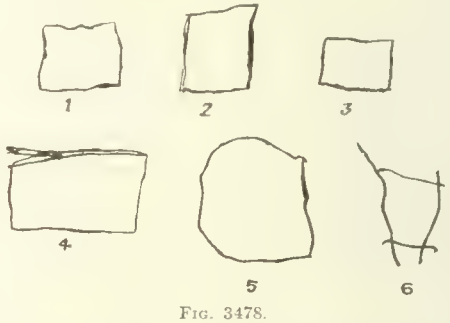

Fig. 3478.

The answers should indicate that the child knows what each is. This is a more difficult use of language than naming objects in the picture because there the child choses his own object to name; here we say, "What is that thing?"

3. *Repetition of Three Figures.* "7–2–9." [Child must succeed on one out of three trials, each trial being a different group of figures.]

4. *Comparison of Two Lines.* "Which is the longer line?" Show a card on which are drawn two parallel lines 3 centimeters apart, the one 5 centimeters and the other 6. Hesitation is failure. [Say to child, "Do you see these lines?" "Tell me which is the longer." A correct response must be given without hesitation three times. Vary position of long line from top to bottom by turning card around. Be sure the judgment is real and not accidental.]

Children of Five Years.—1. *Comparison of Two Weights.* "Which is the heavier?" Use weighted blocks of wood of equal size and appearance. Compare 7 grams with 12 grams and 6 grams with 15 grams. Note the curious and interesting errors that are made. [It is a test of perception of difference. If you have no 3 gram weights, use 6 and 15, and 9 and 18. Two judgments out of three must be correct. Have heavier at right on one trial and at left on next trial.]

2. *Copying a Square.* Show a square of 3 or 4 centimeters. Have child copy it with ink—not pencil. Pen makes it harder. It is satisfactory if one can recognize the square. In Fig. 3478, Binet considers 1, 2, 3, acceptable, 4, 5, 6, not acceptable. [Pen and ink seem a little hard, so hereafter pencil will be used.]

* These pictures as well as other materials needed for the tests can be obtained of C. H. Stoelting Company, 127 Green Street, Chicago.

3. *Repeats Sentence of Ten Syllables.* Use this: His name is John. He is a very good boy." [All ten syllables must be repeated *verbatim.*]

4. *Counting Four Pennies.* Place four pennies in a row. Insist that child count them with his finger. At three years a child does not know how to count four: at four half succeed: at five all succeed.

5. *Game of Patience with Two Pieces.* Cut a visiting card diagonally. Place a whole card on the table. Nearer the child place the two pieces with the two hypothenuses away from each other. Ask the child to make a figure like the uncut card. One child in twelve fails. Be careful (1) that child does not fail because he is too indolent to reach out and try: (2) that one of the pieces does not get turned over—because then it is impossible: (3) that you do not show by a look whether the child is right or wrong. [Give the child no suggestion, place the two triangles before him with the long legs facing each other and somewhat separated.]

Children of Six Years.—1. *Distinction between Morning and Afternoon.* "Is this morning or is it afternoon?" It should be remembered that a certain type of child will always answer the second of two alternatives. Therefore if the time is afternoon, it is well to put the question, "Is this afternoon or morning?" Not before six do children know this. [Is a test of perception of passing time and often develops a little late. As in Four, 1 and 4 be sure the answer is not accidental. If in doubt, repeat question later.]

2. *Definition of Known Objects.* "What is a fork? a table? a chair? a horse? a mama?" There are three kinds of response. (1) Silence, simple repetition, or gesture. *e.g.* "A fork is a fork," or pointing says "That is a chair." (2) Definition in terms of use, "A fork is to eat with." (3) Definitions *better* than by use. This includes all answers that describe the thing or even begin with "it is a thing"—"it is an animal," etc., all of which expressions are not so childlike as the simple "*use*" definitions. In deciding which type of answer we shall credit to the child, we accept three out of five. At four years half the children define by "*use*": it increases a little at five and at six practically all define this way. Not before nine do the majority give the definitions that are "*better than by use.*" [Test of language and ideas—silences or mere repetition of question or pointing are counted failure, *e.g.* "a horse is a horse," or "this is a table" (touching one). Child should respond with definition by use to at least three out of five to be credited at age of six, and by three out of five definitions superior to use at the age of nine. *Do not credit automatisms.*]

3. *Execution of Three Simultaneous Commissions.* "Do you see this key? Put it on that chair. Then shut the door. After that bring me the box that is on the chair. Remember, first the key on the chair, then close the door, then bring the box. Do you understand? Well, then, go ahead." Such are the directions. They must all be done without further help, hint or suggestion. At four years almost none can do this, at five about half: at six all, or nearly all, succeed. [Give clear directions—then repeat them, and after that give the child no more help. *Be sure the three commissions are not conflicting, ambiguous, or unusual.*]

4. *Right Hand. Left Ear.* One says to child "Show me your right hand" and when that is done "Show me your left ear." There are, in the main, three kinds of response. (1) Does not know right and left. Shows right hand because of natural tendency. Shows right ear also. (2) Knows but is not sure. Shows right hand, then right ear but corrects himself at once. (3) Knows and without hesitation touches right hand and left ear. (2) and (3) are considered satisfactory. If child touches one hand with the other in such a way that one cannot tell which hand he means, ask him to hold his right hand up high. Be very careful in this test to give no hint by look or word. At four years no child points to left ear: at five half of the children make a mistake: at six all succeed. [Accept if done immediately or with slight hesitation. Other parts of the body seem harder. If examiner has given no sign of disapproval, a prompt correction on part of child must be accepted.

Fig. 3479.

5. *Esthetic Comparison.* "Which is the prettier?" Binet uses six heads of women in three pairs, the one pretty and the other ugly or even deformed (Fig. 3479). Care is taken that the pretty one is now at the left and now at the right. At six all choose correctly: at five about half. [Child must give all three comparisons correctly.]

Children of Seven Years.—1. *Counting Thirteen Pennies.* Pennies must be placed in a row and counted with the finger. Finger must touch the piece at the same time that the child names the number. No piece may be counted twice and none omitted. The number thirteen must be given exact. At six years two-thirds fail: at seven they make no errors.

2. *Description of Pictures.* Same pictures as used in age three. Child now sees action instead of simply enumerating. [See age three, question 4. Now he must report action in at least three pictures, *e.g.* mowing lawn, cutting hair, etc.]

3. *Unfinished Pictures.* One shows four sketches of such as Fig. 3480. Ask the child "What is lacking in that picture?" Child must answer three out of four correctly. At five years none are correct: at six errors number two-thirds, at seven the great majority are accurate. [Give *encouragement,* but not *help.* Ask each time "What is missing (or lacking) in this picture?" Vary question to enable child to understand what is wanted.]

4. *Copying a Diamond.* Show a rhombus about the size of the square used for age five. Have child copy this with pen. The result is satisfactory if it would be recognized as intended for a diamond-

shaped figure. In Fig. 3481 Binet considers 1, 2, 3 acceptable, 4, 5, 6 not. [May be done with pencil, as pen is harder.]

5. *Name Four Colors.* Use red, blue, green, and yellow papers, in pieces about 1 × 3 inches. Touching each color with the finger ask "What is that

Fig. 3480.

color?" It will be seen this is a test of color names not of discrimination. It should be done in 6 seconds. [No errors allowed.]

Children of Eight Years.—1. *Compare Two Things from Memory.* "What is the difference between a butterfly and a fly? "Wood and glass?" "Paper and pasteboard (or cloth)?" The question may be differently put so as to make it intelligible

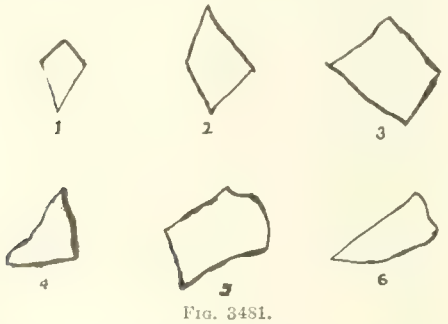

Fig. 3481.

as possible. *e.g.* "Why are they not alike?" etc. Two at least out of the three pairs should be answered correctly. If it takes more than two minutes it is a failure. At six a third of the children do this test: at seven nearly all: at eight all. [Do not accept automatisms. Do not expect *logical* answers. An answer that shows the child has an idea of each object and expresses a difference between them is acceptable, *e.g.* "A butterfly is yellow and a fly is black." "You can tear paper, cloth you can't," are both acceptable answers.]

2. *Count Backward from* 20 *to* 1. This should be done within 20 seconds, and only one mistake allowed of omission or transposition. Hold pretty strictly to time.

3. *The Days of the Week.* These must be given in order without omission within ten seconds. Most persons would expect that this could be done before age eight, but it cannot. [Child must not be given one name with which to start. May begin with any one so long as he names all in order.]

4. *Count Nine "Sous" (3 Simples and 3 Doubles).* (Our two-cent piece is now so rare that we use 1-cent and 2-cent postage stamps.) Arrange in order, 1, 1, 1, 2, 2, 2. "How much are they worth? (How much money to buy them?) "Count." It should be done within ten seconds without any error. There are three ways of counting. One child says 1, 2, 3, 5, 7, 9. Another says 1, 2, 3, 4–5, 6–7, 8–9. The third says, 1, 2, 3, 4, 5, 6, which is of course wrong. A minority do this test at seven years. But nearly all do it at eight. [Be careful of stamp arrangement—111222. Say, "You know how much a green stamp costs (illustrating with one stamp) and how much a red stamp costs (illustrating)? How much do all these cost?"]

5. *Repetition of Five Figures.* "4–7–3–9–5." Same method of procedure as given above, age three. Only three-fourths of the children succeed. [Five figures must be repeated correctly in one trial out of three, each on a different group of figures.]

Children of Nine Years.—1. *Make Change—9 Cents out of* 25. Play store. Using real money. If child's cash consists of 25 pennies, 5 nickels, and 2 dimes, interesting degrees of intelligence will be discovered by noticing the coins he uses in making change. Child is storekeeper. One buys something that costs 9 cents. Child must actually give 16 cents as well as say it. At seven no one can do this test: at eight a good third succeed: at nine all do it. [Real money only must be used and change must be counted out as well as stated (except in cases where child is obviously beyond this test). Use four cents from twenty (two dimes), or six cents from twenty-five as an alternate.]

2. *Definition Better than by "Use."* This was explained under age six. At ages seven and eight, half the children give definitions of this kind. At nine they all do. See age six, question 2.

3. *Name the Day of the Week, the Month, the Day of the Month and the Year.* The test is passed even if the day of the month is as much as three days wrong. Children least often know the year.

4. *The Months of the Year.* Recited in order within 15 seconds. Allow one omission or transposition. [Do not name a month to start the child. Child may begin with any one so long as he names them all in order.]

5. *Arrangement of Weights.* Use five wooden cubes of same size and appearance but loaded so as to weigh 6, 9, 12, 15, 18 grams. (Metal pill boxes may be used). Place the five boxes on table in front of child and explain that they do not all weigh alike and he is to lift them one at a time and put them in order from the lightest to the heaviest. (The initial of each weight written on the bottom of each box makes it easy to see if they are right.) Record the exact order in which the child has placed them. Three trials are made. Two must be absolutely correct. The whole operation ought not to take over three minutes. [Weights are to be arranged in decreasing order. Do not help after child has started, *e.g.* by saying, "Now the heaviest one that is left." Give clear and explicit instructions before beginning the test. Then do not help further on that trial. The instructions may, however, be repeated for a second trial.]

Children of Ten Years.—1. *Naming Nine Pieces of Money.* One may use cent, nickel, dime, quarter, half dollar, dollar, two dollars, five dollars and ten

dollars. Pieces should be on table in a row but not in regular order of value. Point with finger, and name as he points. [Our question differs from Binet's, because our currency does not fit. His test involves *coins*, all of which are in use. Our *coins* above fifty cents are rarely seen by children. Therefore we show coins up to fifty-cent piece (but not in order) these must be named correctly. Then he may name the paper money from memory. If he names 2, 3, 4, 6, 7, etc., dollar bills ask him if he ever saw a 3 and 4, etc.; if he insists that he *has* seen them the question is given no credit, but if he merely knows there is a higher series and does not insist that he knows *from experience* that there are 3, 4 or 7 dollar bills, we credit him.]

2. *Draw Design from Memory.* Tell child you are going to show him two designs on one card; that he is to look at them both for ten seconds and then draw them from memory. (Use Fig. 3482.) It is satisfactory if one design is right and other half right No account is taken of proportions, crookedness of lines or perspective.

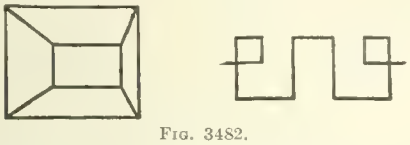

Fig. 3482.

"Tests attention, visual memory, and a little analysis." [We define "half right" as one significant part omitted or two transposed. It is well to emphasize before beginning that child is to draw both parts. Have child draw on back of record sheet.]

3. *Repeats Six Figures.* [One trial out of three correct—use different series each time. Prepare series beforehand so as to avoid same combinations of any two figures in the different series.]

4. *Questions of Comprehension. First Series.* What ought one to do: (1) When one has missed the train? (2) When one has been struck by a playmate who did not do it purposely? (3) When one has broken something that does not belong to one? At seven and eight half respond correctly: at nine three-fourths: at ten all. If two questions out of three are answered correctly the series is passed.

Second Series.

What ought one to do: (1) If he is afraid he will be late for school? [The only correct answer is "hurry" or "run," or some expression of hastening.] (2) Before deciding an important matter?

(3) Why does one excuse a wrong act committed in anger more easily than a wrong act committed without anger?

(4) What should one do when asked his opinion of some one whom he knows only a little?

(5) Why ought one to judge a person more by his acts than by his words?

Allow at least twenty seconds to each question. Three of the five must be answered correctly. Both series must be passed. At seven and eight no one responds to a majority of this second series: at ten half are successful; it is therefore a transition between ten and eleven years.

[Binet says, "Twenty seconds at least must be given for the child to think each question over."]

5. *Using Three Words in a Sentence.* Binet uses the words *Paris, fortune, river.* [We should say *Philadelphia, money, river.*] This is the first time in these tests that we have required the child to "invent" his own expression. There are three forms of answers. (1) Three separate sentences. (2) Two ideas united by a conjunction. (3) A single idea involving the three words. Only the last two are satisfactory for the test. We allow one minute. At eight no one succeeds. At nine one-third and at ten one-half get it right. In this test may be seen a distinction between intelligence and judgment. Some children give a complete sentence with the three words but they do not make sense. [Say, "Do you know what a sentence is?" One may explain, but not illustrate what a sentence is. One then continues, "Put these three words into one sentence" (saying the three words to be used, and nothing else). The sentence may lack good sense and yet be acceptable. We accept a compound sentence or better, but not separate sentences.]

Children of Eleven Years.—1. *Criticism of Sentences.* These are sentences that contain some absurdity or ridiculous expression. Binet explains that formerly he used sentences like "Is snow red or black?" but he found that many bright children fell into the trap and others through confidence in the questioner failed to look for an absurdity. Therefore he has changed the plan and now says to the child, "I am going to give you some sentences in which there is nonsense. You listen carefully and see if you can tell me where the nonsense is." Then he reads the sentence very slowly.

These are the sentences: 1. "An unfortunate cyclist has had his head broken and is dead from the fall: they have taken him to the hospital and they do not think that he will recover."

2. "I have three brothers, Paul, Ernest, and myself."

3. "The police found yesterday the body of a young girl cut into eighteen pieces. They believe that she killed herself."

4. "Yesterday there was an accident on the railroad. But it was not serious: the number of deaths is only forty-eight.

5. Some one said "If in a moment of despair I should commit suicide, I should not choose Friday, because Friday is an unlucky day and it would bring me ill luck."

The test should last about two minutes. Three at least of the questions should receive good answers. At nine years hardly any child gets them: at ten scarcely a fourth: at eleven a half. [Three out of five must be correct. If they seem too gruesome for a particular individual child, use the alternatives.]

2. *Three Words in a Sentence.* (Given under age ten.) At eleven all succeed. [See age ten, question 5. To pass at this age the sentence must be either simple or complex, but not compound.]

3. *Sixty Words in Three Minutes.* "Say as many words as you can in 3 minutes; as table, board, beard, shirt, carriage." We tell him that some children have named 200 words. This test gives a splendid opportunity to appreciate the intelligence of a child. At least sixty words must be given. [Must give at least sixty. Do not credit numbers given serially, nor repeated words if they occur too frequently. Twenty words in one minute or forty in two does not serve to pass the test.]

4. *Rhymes.* Explain what is meant by one word rhyming with another. Illustrate. Then ask for as many words as the child can think of, that rhyme with a given word. *e.g.* "day" or "spring" or "mill." One minute is allowed. Three rhymes with one word should be found in the given time. [Always give an explanation of the meaning of rhymes and an illustration (we use "floor" as an illustration). Do not accept syllables that are not real words although they may rhyme. Three rhymes with each of the three words is required, one minute is allowed for each series.]

5. *Words to Put in Order.* "Make a sentence out of these words:"

1. STARTED—THE—FOR—AN—EARLY —HOUR—WE—COUNTRY—AT
2. ASKED—PAPER—THE—TO—I— —TEACHER—CORRECT—MY
3. A—DEFENDS—DOG—GOOD—HIS— MASTER—BRAVELY

Place the printed words before the child. He gives the sentence orally. Time limit is one minute for each sentence. At least two must be given correctly. [Place words before the child and read them to him to be sure he knows them.]

Children of Twelve Years.—1. *Repetition of Seven Figures.* 2, 9, 4, 6, 3, 7, 5. 1, 6, 9, 5, 8, 4, 7. 9, 2, 8, 5, 1, 6, 4. Tell the child there will be seven figures. Give three trials. One success is sufficient. [Here we warn the child that there are to be seven numerals. Three trials may be given each on a different series—one success is necessary.]

2. *Abstract Definitions.* "What is Charity? Justice? Goodness?" Two good definitions must be given. It is often somewhat difficult to decide if the definition is passable. If it contains the essential idea it must be accepted however badly it is expressed. At ten years a third succeed: at eleven they are generally successful. [Definitions must contain the following ideas:

Charity—unfortunate people and the good one does them.

Justice—idea of law or civil order; *or* the idea of persons treated according to their merits.

Goodness—affectionate sentiment *or* kindness; *or* acts of assistance without implied inequality.

"Charity is love," or "Goodness is doing good," are not acceptable. Ask the question again.]

3. *Repetition of a Sentence of 26 Syllables.*

This should be done without error.

"Children, it is necessary to work very hard for a living. You must go every morning to your school."—24 syllables.

"The other day I saw in the street a pretty young dog. Little Maurice has got spots on his new apron."—26 syllables.

"Ernest is praised very often for his good conduct. I bought at the store a beautiful doll for my little sister."—28 syllables.

"There occurred on that night a frightful tempest with lightning. My comrade has taken cold. He has a fever and coughs very much."—30 syllables.

4. *Resists Suggestion.* Prepare a little booklet of six pages. On first page draw in ink two lines horizontal: the one to the left two inches (4 cm.) long, the one to the right two and a half inches. On second page, left line is two and a half, right, three inches. Third page, left line three and right one three and a half inches. On three remaining pages all lines are three and a half inches long. The lines on each page are in same straight line and separated by a half inch.

The idea of the test is this: Child having said the right-hand one is longer for three times, will he continue even when he comes to those that are alike, or will he "resist the suggestion" and say they are alike?

Care must be exercised in asking the question. For the first two pages ask "Which is the longer line?" but for the others say merely, "And here?"

Present longer line at right each time. At least twice out of the three times the child must see that the lines are equal.

5. *Problem of Various Facts.* (What is it?)—"A person who was walking in the park suddenly stopped much frightened and hastened to the nearest police and reported that he had seen hanging from the limb of a tree a———" (after a pause) "what?"

(2) "My neighbor has been having strange visitors. He has received one after the other a physician, a lawyer, and a clergyman. What has happened at the house of my neighbor?"

Both questions should be answered correctly. The answer to the first is "a dead man." Some object to this story as too gruesome. Others say that children are not so sensitive to such things as we think. Aside from that question it would seem that the picture is hardly familiar enough in America to make the answer certain. A substitute should be found. [Binet says right answer to *A* must involve idea of a corpse, and to *B* the idea of some one very ill—if answers are indefinite query further and be sure whether child has correct idea or not before crediting.

"Fifteen years" and "Adult" have not proved reliable, therefore we do not include them in the scale.]

Since Binet first suggested this scale many other tests of intelligence have been proposed. One of the most valuable of these tests is that proposed by Professor Sante de Sanctis of Rome, Italy. It is a scale of six questions, and while not closely marked off for the years of child life, it reaches practically to the age of seven years. Dr. de Sanctis proposed it as a test for mental defect. His conclusion is, that any child who can answer all of the questions is not mentally defective. De Sanctis meant that the child is not an imbecile. Morons pass all six of the tests.

Of the later tests that have been proposed, few, if any, have been standardized. That is to say, their authors have not told us the age at which they should be successfully accomplished. This is a vital point, and absence of standardization renders these tests valueless for practical purposes. Solving a puzzle with blocks may be a most excellent test of intelligence, but unless we know the age at which children in general can solve a particular kind of puzzle, it gives us no information as to the intelligence of the individual. It may be a puzzle so involved that only an adult can solve it; on the other hand, it may be a puzzle that can be solved by a child of five. The determination of suitable tests of intelligence must be made by first devising some that seem theoretically good and then trying them out on hundreds or thousands of persons of all ages, and from this discover the age at which the test is first successfully accomplished. When one finds a test that is successfully answered by seventy-five per cent. of all persons of some one age, is answered by fewer persons of a younger age and by more of an older age, then he has a good test for the age at which it is correctly answered by seventy-five per cent. of all who try it.

We have said that the Binet scale ends at the age of twelve. There is a great need for tests beyond this, at least up to age twenty. Tests for these ages, however, seem to involve an added difficulty. It is apparently true that whereas the mind seems to develop up to the age of twelve in what we may call a linear way, or in one dimension, from this point on, the development seems to be in two or three dimensions. In other words, the individual begins to get a specialty and a man may be highly intelligent in the direction of his specialty and relatively unintelligent along other lines. It becomes necessary therefore, first to discover his specialty and then to test his ability in that line. The difficulty is illustrated by some of the questions that Binet proposed for ages above twelve. Some can do them readily, others who, tested by the experience of life, are fully as intelligent fail utterly.

Difficult as is the problem of getting tests for intelligences beyond that of the twelve-year child, the problem is not hopeless, and we shall undoubtedly have before long satisfactory tests far beyond those that we now possess.

The practical success of the tests already formulated has an important bearing upon psychological theory. One of the prominent theoretical objections to tests of intelligence has been that intelligence being a matter of attention, memory, judgment, emotion, will-power, and perhaps many other so-called mental processes, it must be impossible to measure it. The fact, however, that it is measured, that the tests do determine an intellectual level which agrees exactly with experience, has given rise to the theory now definitely set forth particularly by certain English psychologists, that intelligence itself is a unit; in other words, that there is such a thing as general

intelligence, which can be tested and measured. This has been set forth by Abelson, Cyril Burt, Spearman, and other English psychologists. It may be only another way of stating what has long been held but inadequately appreciated, that the mind is after all a unit and that what we call memory, attention, etc., etc., are only special manifestations of mind or intelligence and the terms are largely fictions which the psychologist evolves in his attempt to study the mind.

The literature on the subject of tests of intelligence is now too voluminous to quote. The reader will find a bibliography, fairly exhaustive up to the time of its publication, in the *Journal of Educational Psychology*, May and June, 1914. Henry H. Goddard.

Intention Tremor.—Intention tremor is a form of tremor occurring only upon voluntary movement, the oscillation being in general perpendicular to the direction of this movement and becoming more marked the greater the effort, though not preventing the desired end being attained. The tremor ceases during rest. It is made manifest in the upper extremity upon attempts to touch the nose with the finger or to bring a glass of water to the lips, in the lower extremity, when the patient attempts to touch his knee with the heel of the opposite side. It is found as a characteristic symptom in multiple sclerosis, in which disease its production is thought to depend upon the fact that since it is the myelin sheath and not the axis cylinder which is affected, in many places the insulation of the nerve fibers is destroyed so that conduction of impulses takes place in an irregular way. It is also found occasionally in cerebellar diseases and in organic hemiplegia.

Charles Lewis Allen.

Intermittent Fever.—See *Malaria*.

Intertrigo.—See *Eczema*.

Intestinal Movements.—Methods.—The different procedures ordinarily employed to expose the abdominal organs usually incite such marked changes in the motor efficiency of the intestines that their movements can no longer be regarded as identical with those occurring under perfectly normal conditions. The manipulations of these parts, as well as the entrance of air and the lowering of the temperature, generally induce a refractory state in these organs which it is often difficult to overcome by artificial means. Naturally, these influences are brought to bear peripherally, and hence, the nervous receptors here involved are the terminals of the abdominal sympathetic system. Various precautions may be taken to avoid this motor disturbance; for example, the peritoneal cavity may be opened in a bath of warm saline solution, or the organs may be protected against outside influences by inserting a rounded piece of glass in the incision. In some animals (rabbit) it is possible to thin the abdominal wall sufficiently to observe the organs without actually exposing them and, moreover, if food mixed with large quantities of bismuth is ingested, the intestinal contents may be made to throw a shadow upon the sensitive screen by means of the Röntgen rays.

The attempt has been made at an early date to supplement the data derived from observations by graphic records. This end can readily be attained in animals possessing a thin abdominal wall by placing a receiving tambour upon the external surface and directly over that part of the intestine the movements of which are to be recorded, but naturally the fewest difficulties will be encountered if the parts are exposed and are made directly accessible to the writing lever. Different segments of the gut may be removed from the body and, when placed in a moist chamber or in a receptacle containing normal saline solution, their behavior may be studied either by connecting them with the recording lever directly or by inserting a receiving bulb in the intestinal canal. A special pneumograph, generally spoken of as ecterograph, may be applied to the external surface of the segment. Different investigators have sought to avoid the motor disturbances referred to above by extirpating parts of the solar plexus or by dividing the splanchnic or vagi nerves.

Movements of the Small Intestine.—The arrangement of the musculature of the intestine is simple. An outer, relatively thin, coat in which the individual fibers are arranged longitudinally, lies in relation with a layer in which the fibers are directed circularly around the lumen of the intestine. The latter in turn is limited internally by the very slight and functionally unimportant muscularis mucosæ. It should be remembered, however, that the many morphological differences displayed by the different segments of the intestine also embrace variations in the amount of the muscular tissue. Thus, the jejunum is large and muscular, while the ileum is narrow and possesses thin coats. Similar differences are encountered in the duodenum.

The combined action of the muscular layers gradually forces the chyme onward, mixing it thoroughly with the digestive juices, facilitating absorption, and finally expelling the undigested remnants of the food and various excreta into the rectum from which it is removed by the act of defecation. Two main types of movements are possible, namely, circular constrictions which occasion a lessening of the intestinal lumen and a lengthening of the gut, and longitudinal contractions which increase the size of the tube and reduce its length. Ordinarily, however, the contractions of the two coats of muscle tissue occur together so that the movements produced must be regarded as the product of the two layers, *i.e.* neither the constrictory nor the pendular motions can be said to be wholly dependent upon the contraction of one or the other of the layers referred to. The wave of constriction which passes slowly from one part of the intestine to the other is known as *peristaltic movement*, while the localized contractions and expansions of neighboring coils are called *pendular movements*. As the latter occur at regular intervals, they are frequently spoken of as the rhythmic movements. Under ordinary conditions the peristalsis is sweeping in character and extends over long sections of the gut, driving the contents onward in the direction of the cecum. Sometimes, however, it is fragmentary and remains confined to rather circumscribed portions of the gut. The advancing ring of constriction is preceded by an area in which the intestinal wall is relaxed; in fact, the entire tube is somewhat enlarged at this point. The bolus is therefore forced onward by the circular constriction, while at the same time the resistance ahead of it is reduced to a minimum, but naturally, the mass within cannot assume a transverse position, because the longitudinal muscle fibers still retain a certain degree of tension which keeps the bolus in the long axis of the gut. The influence of the outer layer of muscle tissue is made especially apparent when the peristalsis is augmented; the intestines then exhibit peculiar writhing or vermicular movements.

A definte point of origin of these peristaltic waves cannot be made out with clearness at all times. While they always arise above, a "pace-maker" does not seem to exist in any particular locality. Bayliss and Starling,[1] hold that the production of the peristaltic wave depends on the response of the intestinal nervous mechanism to local stimulation, *i.e.* whenever an irritation arises, an excitation results above this point and an inhibition below it. Any part of the intestine is, therefore, subject to these opposing influences which are then propagated downward to neighboring segments. To illustrate, a peristaltic wave may be

excited in an isolated loop of intestine by inserting an oblong object into its upper portion. Shortly afterward the end segment shows pronounced activity finally culminating in a strong wave of contraction, in consequence of which the object is eventually expelled through the lower opening. Moreover, on introducing the object from below, it is soon forced out through the same opening; in fact, the intestine frequently contracts so strongly that the upward passage of it can be accomplished only with difficulty.

Two theories are held regarding the origin of the peristaltic waves, namely, the myogenic and the neurogenic. The former assumes that the stimulation arises in the myoplasm and that the wave is propagated from muscle fiber to muscle fiber; the latter, on the other hand, implies that the excitation is of nervous origin and that its onward passage is made possible by the intricate network of nerve fibers connecting the different intestinal segments. The early experiments of Bayliss and Starling, made upon exposed loops of intestine after the application of nicotine, tend to affirm the belief that the movements are myogenic, while those of O. Cohnheim[2] and Magnus[3] suggest that under normal conditions the nervous elements play by far the most important rôle. Thus, it was found that the movements in isolated segments continued with unimpaired rhythm if the mucosa and submucosa were removed, and furthermore, it was shown that if the inner and outer layers of muscle tissue were separated from one another in such a manner that the plexus of Auerbach remained attached to the latter, the circular muscle fibers ceased their activity, while the longitudinal fibers continued to contract rhythmically. Clearly, as these contractions must depend upon a proper connection of the muscle cells with the local sympathetic ganglion, they cannot be regarded as myogenic. Yanase's[4] observations seem to strengthen this deduction, because intestinal movements in embryo rabbits and the human fetus do not occur until nervous elements have made their appearance in the muscular coats.

It may be concluded, therefore, that peristaltic contractions arise in any portion of the gut upon a mechanicochemical stimulation of the neuromuscular receptors by the mass of the chyme within. A diphasic wave results, *i.e.* a wave composed of a ring of constriction preceded by an area of relaxation which, under normal conditions passes toward the cecum. The peristaltic movements therefore are true reflex acts made possible by the coordinated action of the local nervous system. Neither the cerebrospinal system nor the sympathetic ganglia are essential for this activity, because it is possible to isolate portions of the gut from central influences entirely without seriously disturbing these movements. Evidently, therefore, each intestinal segment contains complete reflex arcs, *i.e.* it embraces (*a*) an afferent path with its receptor, (*b*) a center, and (*c*) an efferent path with its motor end organ. An efficient correlation between these different peripheral centers and their receptors and effectors is made possible normally by major centers which are located in the mesenteric ganglia of the solar plexus. It seems that these elements in the solar plexus dominate this entire system. They are connected, on the one hand, with the peripheral nervous elements in the plexuses of Meissner and Auerbach by the multitude of fibers constituting the mesenteric plexus, and, on the other, with the cerebrospinal system by way of the vagi and splanchnic nerves.

We have, therefore, first a peripheral sympathetic nervous mechanism in the walls of the intestines and secondly, a central sympathetic nervous mechanism in the mesenteric ganglion of the solar plexus. It has been shown by Burton-Opitz[5] that the two systems are connected by the mesenteric plexus and that this entire complex is united with the cerebrospinal system by means of the vagi and splanchnic nerves. The former are largely afferent and the latter efferent, and hence, impulses generated in the intestines find their way into the central nervous system by way of the suprarenal and gastric plexuses and the vagi nerves.

It must be remembered, however, that the aforesaid nerves contain, in addition, a certain number of efferent fibers for the musculature of the intestines, because their stimulation is always followed by an increased peristaltic activity. For this reason, the vagi are known as the musculomotor nerves of the intestine. The splanchnics, on the other hand, are inhibitory in their nature in so far as their excitation produces a marked muscular inactivity. This result may, however, be brought about indirectly, because these nerves possess a vasoconstrictor influence and hence, the intestinal reaction may be solely the result of a lessening of the blood supply. To summarize, the foregoing account calls attention to: (*a*) the relative independency of the intestine from central parts, (*b*) the perfect correlation between neighboring segments, and (*c*) the ease with which communication can be established between it and the central nervous system for purposes of systemic reflex reactions of all types.

Under perfectly normal conditions, the peristaltic wave is descending. This fact was made evident by the experiments first made by Mall, in which certain loops of the intestine were resected and again united with the neighboring segments in an inverted position. Thus, the lower end of the loop was made continuous with the upper part of the intestine, while the upper end of it came to lie nearest the ileocecal valve. At autopsy, all of the many different animals operated on showed a fusiform enlargement of the intestine involving principally the part in the vicinity of the upper suture. An accumulation of the ingesta always resulted at this point which sooner or later caused profound and fatal disturbances in the nutrition of the animals. It seems that the inversion of a segment of the intestine blocks the downward movement of the intestinal contents, because the descending peristaltic waves not only fail to excite similar waves in the inverted loop, but are antagonized here by waves moving in the opposite direction.

Normal peristaltic waves progress slowly and do not develop a considerable degree of pressure. Cash,[6] who has made the attempt to measure the power of the waves in dogs, states that a weight of five to eight grams applied upon the external surface of the intestine, is sufficient to hinder the progression of the bolus It may be said that the movements are more rapid and more powerful in the duodenum and jejunum than in the ileum. In the former they occur at the rate of from fourteen to twenty-two in a minute, and in the latter, with a frequency of from twelve to eighteen in a minute. They pass over the gut with a speed of two to three centimeters in a second. Naturally, various conditions may arise at any time which greatly alter this rate; for example, the peristalsis becomes more vigorous shortly after the contents of the stomach have been discharged into the duodenum and when the different secretions are poured into this part of the intestine. They are retarded and abolished during sleep and may be incited at any time by chemical, mechanical, electrical, or thermal stimuli.

In accordance with the experiments of Engelmann[7] of stimulating excised loops of small intestine, it has always been assumed that this part of the alimentary tract is also the seat of peristaltic waves of an ascending type. While more recent tests upon living animals have shown rather conclusively that such retrograde or antiperistaltic movements do not occur under normal conditions, it is possible that they arise at times in consequence of pathological lesions. At least, the entrance of fecal masses into the stomach, consequent to obstruction of the lower bowel, has been explained in this way but, naturally, a retrograde movement of this kind may occur quite independently

of the contractions of the intestinal musculature. Thus, it is conceivable that the pressure developed under these conditions by the abdominal muscles alone suffices to force the intestinal contents upward in the direction of least resistance.

The pendular, or rhythmic movements of the small intestine consist essentially of rapid to-and-fro contractions in neighboring coils, whereby a motion is imparted to the entire segment which may be imitated by walking a step or two in advance and suddenly retracing the steps taken. These alternate contractions and relaxations occur rhythmically and are interrupted every now and then by a peristaltic wave which generally sweeps directly through this field of great oscillatory muscular activity. A comprehensive study of these motions has been made by Grützner[8] who was able to analyze them by mixing insoluble substances, such as nitrate of bismuth, with the ingesta. Cannon,[9] in particular, has carefully observed them with the help of the Röntgen rays by adding bismuth subnitrate to the food. He finds that the large accumulations of chyme are suddenly divided into many smaller portions, while, a moment later, the small segments are again united into more voluminous masses. In the cat this segmentation is repeated rhythmically for some time and at the rate of thirty in a minute. It is obvious that this type of movement, being largely dependent upon the constrictions of the circular musculature, cannot produce a steady onward progression of the food, but merely causes it to change its position repeatedly within a rather limited area of the intestine so that it becomes more thoroughly mixed with the secretions. It need hardly be mentioned that this process greatly augments and hastens digestion as well as absorption. Cinematographic records of the progress of the food have been taken by Carvallo (1907) and others.

The muscular activity of the small intestine in man has been studied radioscopically by several observers, but the results have not been very convincing, because the anatomical arrangement of the coils and the quick dissemination of the bismuth-chyme through them, greatly hinder the formation of shadows of sufficient compactness to be used for an exact analysis of these movements. Recently, however, Küpferli[10] has succeeded in obtaining pictures which seem to show that the movements met with in the human small intestine are very similar to those observed in other animals. Long peristaltic waves occur synchronously with local oscillatory or pendular motions. While the former cause a steady progression of the contents toward the cecum, the latter serve to subdivide the masses of chyme into smaller portions and to change their position constantly so that they become thoroughly mixed with the digestive juices. Antiperistaltic movements do not occur in this part of the intestines under normal conditions.

Movements of the Large Intestine.—The function of the large intestine is so widely different from that of the small intestine that the two parts may almost be regarded as separate organs. In the carnivora, the process of absorption is practically finished at the ileocecal valve, while in the herbivora a large part of digestion and absorption occur in the proximal segments of the large intestine. Man occupies an intermediate position in this regard, but as the human large intestine is very long and possesses a spacious cecal vestibule and a peculiarly indented transverse colon, it more greatly resembles that of the herbivorous group of animals. The functional diversity alluded to is clearly portrayed in the different motility of these parts.

The ileocecal valve is a sphincter formed by a heavy ring of musculature which is capable of greatly lessening the size of the communication between the small and large intestines. Whether this orifice can be closed absolutely against the contents of the cecum is still a disputed point, because the two flaps of the valve are of unequal size and are so placed that they do not seem to be able to unite firmly. Moreover, it has been demonstrated that rectal and colon infusions may in time reach the ileum without being actually forced upward, and that portions of the contents of the ascending colon are at times returned into the ileum. It must be concluded, therefore, that the competency of the valve is only relative, *i.e.* it is sufficiently strong to hinder the regurgitation of the chyme into the ileum under ordinary conditions of pressure. At the same time it is evident that the chyme does not pass unrestrictedly into the cecum, but is dammed back in the ileum to be sent through the aforesaid orifice periodically and in large gushes. This valve, therefore, must be controlled by a local reflex mechanism, the activity of which depends upon a mechanicochemical stimulation by the intestinal contents.

The large intestine proper may be divided into four parts, namely, into the cecum and the ascending (proximal), transverse (intermediate), and descending (distal) portions of the colon. The musculature possesses here the same general arrangement as in the small intestine and hence, it may be surmised that the movements exhibited by it are similar to those described previously. Bayliss and Starling hold that the law of intestinal peristalsis formulated by them also applies to this division of the alimentary canal. Regular peristaltic waves which are characterized by contractions preceded by areas of relaxation occur simultaneously with pendular motions. It is to be noted especially that a third type of intestinal movements, namely, antiperistaltic contractions, occur throughout the large intestine. These motions which were recognized at an early date and have been clearly perceived in rabbits and cats by Jakobi[11] are particularly in evidence in the proximal colon. In general, however, the movements are less frequent than in the small intestine so that the organ, even at the height of digestion, presents the appearance of almost complete motor inactivity. This behavior is in harmony with the time consumed by the food in its passage through the alimentary canal. To illustrate: while the human small intestine which measures about 7 m. in length, is traversed by the food in from eight to nine hours, the large intestine, the length of which amounts to only 1.5 m., is passed in scarcely less than twenty-one hours.

The regular descending peristalsis of the large intestine consists of precise and coordinated waves of contraction incited reflexly with the help of the plexus of Auerbach. They involve, as a rule, extensive portions of the gut, but occur at relatively long intervals. Every now and then more powerful and more extensive waves of the same type appear which move the contents onward for a distance of from ten to twenty cm. and are accompanied by noises and sensations designated by Kussmaul as "tormina intestinorum." Three or four movements of this kind suffice to carry the feces into the rectum; in fact, Schwarz[12] believes that they always precede and incite defecation, because they dislodge large masses from the transverse colon which eventually stimulate the nervous receptors of the lower bowel. These waves become especially conspicuous under pathological conditions, as for example, in diarrheal colic or after the ingestion of irritating substances.

On leaving the ileum, the chyme enters the proximal colon, where it incites motions which are commonly designated as antiperistaltic. It must be remembered, however, that these movements are not the exact antithesis of the regular peristaltic waves, because they do not occur in antagonism to these and do not show a true diphasic character. As they arise most frequently in the neighborhood of the junction of the ascending and transverse portions of the colon and

travel slowly toward the ileocecal valve, their tendency is to force the intestinal contents into the cecum. Here, however, a certain resistance is encountered which causes the mass of food to recoil and to regurgitate in the direction from which it came. Moreover, as the walls of this intestinal segment are not straight but possess saccular enlargements, the effect of these antiperistaltic waves is to subdivide the entire mass into smaller portions which are constantly turned over and over along the wall and are repeatedly forced back toward the cecum (haustral churning). These antiperistaltic waves are succeeded every now and then by regular peristaltic waves which carry the food onward into the transverse colon. Gradually a large amount of water is absorbed. The firmer material escapes into the transverse colon, while the soft masses are again driven back by the ascending contractions.

Antiperistaltic activity is encountered principally in the cecum and in the ascending colon, while regular peristalsis is seen largely in the distal segment of the transverse colon as well as its descending portion. Prompted by his radiological observations of the normal movements in cats, Cannon[13] divides the large intestine of these animals into parts, the dividing line corresponding roughly to the median segment of the transverse colon. On the proximal side of this line the most frequent movement is that of antiperistalsis, while on the distal side regular peristalsis prevails. In general, therefore, it may be said that the proximal portions of the large intestine are the seat of the greatest functional activity, while the distal portions serve merely as places for the storage of the feces until sufficiently bulky to be forced into the rectum. The descending colon, however, does not remain filled for any length of time, because the material collects chiefly in the sigmoid flexure.

Elliott and Barclay-Smith[14] have shown that the antiperistalsis of the proximal colon is present in a great variety of animals. It is especially pronounced in the herbivora in which the cecum serves as a large, thin-walled reservoir for the bacterial decomposition of the food. After its entrance from the ileum it is repeatedly forced back into this pouch where it often remains for days, undergoing digestive changes. As cellulose constitutes a most important source of nourishment of these animals, it must be thoroughly digested. While carnivora (dog) do not reduce cellulose, omnivora (man) do, and hence, the motility of the large intestine differs somewhat in different animals. In man, the cecum and adjoining colon remain much distended for some time after the entrance of food from the ileum; in fact, the aforesaid segments are generally the most conspicuous portions of the large intestine. When filled, they assume a position low down in the abdominal cavity so that the hepatic flexure comes to lie at a much lower level than the splenic flexure. The transverse colon then assumes a very oblique position which in itself serves to hinder the escape of the cecal contents and prolongs the time of digestion and absorption materially. In accordance with Roith[15] human cadavers generally show a filled condition of the proximal colon, while the distal portions are empty. Reider's[16] radiological studies clearly show that the movements of the human large intestine are identical with those observed in animals.

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Intestinal Obstruction.—Definitions.—It is customary to define intestinal obstruction as a more or less complete blocking of the lumen of the gut at a given point, and the consequent more or less complete stoppage of the onflow of the contents of the canal.

The lesser degrees of interference are sometimes incorrectly described as constipation, obstipation, chronic intestinal stasis—terms which are, applied likewise to individual symptoms of intestinal obstruction, or, as in the case of stasis, to the symptom complex which results from certain forms of obstruction. A certain carelessness and confusion of terminology is therefore notable in a great deal of the literature concerning the subject under discussion.

Intestinal obstruction is also described as *acute* and *chronic*, *dynamic* (mechanical), and *adynamic* (paralytic).

Obstruction, when complete, is, of course, acute. Retardation, however, of the onflow of the intestinal content is generally characterized by chronicity. Obstruction may result from causes which are acutely active, and which are generally of a mechanical rather than a functional character. On the other hand, the causative factor or factors which lead to retardation, and which may eventually lead to complete obstruction, may be long active, and for this reason the condition may be called chronic. Just as soon, however, as the effect is sufficiently marked to amount to complete obstruction, the condition at once assumes the characteristics which warrant the application of the term acute.

For these reasons, some authors describe intestinal obstruction under three classes, namely, acute, chronic, and chronic obstruction which has terminated acutely.

In this connection it may be well to define various other terms which are employed in connection with the discussion of intestinal obstruction.

Constipation, which has been defined as a "pathological condition characterized by insufficient fecal evacuation,[1] is generally considered as involving the large bowel, particularly in its lower part. This may exist to a marked extent and yet the patient may suffer very little from the effects of absorption of the retained effete material and its toxins. This results, as a rule, from improper diet, insufficient fluid intake, lack of exercise, or a general atonic condition of the body tissues.

Obstipation is a pronounced and intractable form of constipation.

Chronic intestinal stasis is a term first employed by Sir W. Arbuthnot Lane, of London, to signify "that the passage of food along the alimentary canal takes place with such slowness that there is formed an excess of toxic matter, especially in the small intestine. Consequently, the blood flow pours into the transforming and excretory organs a quantity of poison larger than they can eliminate. From this it results that all the tissues of the body, drenched in this blood rich in poisons, degenerate and offer a diminished resistance to infection. A defective drainage has consequences which are deleterious to the organism in general as well as to the individual tissues of which it is composed."[2]

From this definition it will be noted that chronic intestinal stasis and constipation are not synonymous terms, and that chronic intestinal stasis is not "a descriptive name for the old disease, constipation."[3]

Constipation may exist to a marked degree and yet there may be virtually no autointoxication, which is always characteristic of stasis. Stasis, on the other hand, may be accompanied with constipation or diarrhea, as the case may be, the residual feces being sufficient to give rise to the symptoms, in varying degree, of autointoxication.

Ileus is a term applied to another symptom of intestinal obstruction which, by many, is used to describe the condition itself. It is an ancient term incapable of precise definition, and therefore should not be used. It is often employed to signify paralytic dilatation of the intestine, but has been applied to any form of abdominal distention, and is sometimes used as synonymous with intestinal obstruction.[4]

Etiology.—The way-stations, so to speak, between the normal patency and function of the intestinal canal and complete obstruction at a given point, with consequent loss of function, are many and diverse. Some of these are insidious and slow in their onset, giving rise to the suggestion of chronicity; others are rapid, requiring prompt surgical intervention to prevent fatal results.

Inasmuch as it is customary to consider the subject under the two heads, *acute* and *chronic*, no departure will be made here. It may be stated, however, that the third class of obstruction mentioned by some authors, namely, chronic cases which suddenly become acute, will be considered under the head of acute obstruction.

Acute Intestinal Obstruction.—The etiological factors concerned in the production of acute intestinal obstruction may be grouped as follows: (1) Congenital atresia. (2) Internal hernia. (3) Strangulation by bands, or through mesenteric or omental apertures. (4) External hernia (this is considered elsewhere). (5) Volvulus. (6) Intussusception (acute). (7) Paralysis (reflex, toxic, essential—from shock or trauma during abdominal operation), ("adynamic ileus"). (8) Spastic strictures (generally in neurasthenics). (9) Foreign bodies (sudden impaction by).

Chronic Intestinal Obstruction.—The causes of chronic intestinal obstruction may be broadly classed as *extrinsic*, and *intrinsic*, under which, respectively, come the following:

(1) *Extrinsic:*
1. Abdominal tumors.
2. Adhesions (cicatricial, from tuberculosis, peritonitis, or other inflammatory or infectious process within the peritoneal cavity).
3. Bands (evolutionary, as described by Lane in connection with chronic intestinal stasis; congenital, as described by Treves, Jonnesco, Douglas Reid, and others).

(2) *Intrinsic*, of which two classes are to be considered:

a. Changes in the bowel wall:
1. Intussusception (chronic).
2. Strictures:
   Congenital.
   Due to: Malignant ulceration, Tuberculous ulceration, Typhoid ulcers, Duodenal ulcers, Dysenteric ulcers, Syphilitic ulcers, Ulcerative colitis, Spontaneous cure of intussusception by sloughing.

b. Causes in interior of bowel:
1. Foreign bodies (swallowed).
2. Foreign bodies (of internal origin): Enteroliths, Gallstones, Hair-balls, Impacted feces, Ascaris lumbricoides.

3. Polypi
4. Cysts
5. Malignant tumors

(3, 4, 5: involving the wall of the gut, yet acting as a foreign body within the lumen of the bowel.)

Symptomatology.—In the limited space allotted to the subject under discussion it is manifestly impossible to give in detail the symptoms which generally characterize intestinal obstruction as caused by the various factors enumerated. In the main, therefore, the most characteristic and uniformly present symptoms are catalogued. Whatever the cause, the primary and uniform result of intestinal obstruction is *a greater or lesser degree of interference with the passage of the intestinal contents.*

Acute Intestinal Obstruction. The symptoms vary with the cause of acute intestinal obstruction, but in a general way it may be said that the condition is characterized by the following:

(1) *Pain.* Marked acute abdominal pain, which is the first subjective symptom noted, may come on without any apparent cause in an otherwise perfectly healthy person, or it may follow a severe physical exertion or a violent effort at defecation. The pain is usually first noted in the region of the umbilicus or epigastrium. It soon becomes "colicky" and intermittent, and is always persistent.

(2) *Collapse*, which may be of a marked degree, with extreme pallor and thready pulse, may follow immediately upon the onset of the pain, or it may gradually appear, after an interim of a few hours, or even after several days, if the obstruction is very low.

(3) *Nausea* is soon manifest, and is persistent.

(4) *Vomiting* and eructation give no relief from the terrible nausea. The higher up the obstruction is located in the intestinal canal, the earlier the appearance of vomiting; conversely, the lower down the obstruction, the later the appearance of this symptom. At first the vomitus contains merely the stomach contents, but as the case progresses it becomes stercoraceous. Fecal vomiting was formerly considered a pathgonomonic sign of acute intestinal obstruction, and operative intervention was delayed until its appearance. In a general way it may be said that fecal vomiting accompanies acute obstruction, but it is not always the case, and operation should not be delayed for the appearance of this symptom. In an obstruction low down fecal vomiting may appear when it is too late for operative intervention.

(5) *Fecal stoppage* is the cardinal sign of acute intestinal obstruction. When complete, neither feces nor flatus pass. Sometimes, when the lower bowel is not involved in the obstruction, it will be emptied early in the course of the affection, and may obscure the diagnosis. The constipation, in these cases, does not come on gradually, without the patient's knowledge, but suddenly. Despite the absence of tenesmus the patient may be conscious of difficulty in the passage of gas and feces, and experiences the feeling that relief would follow the evacuation of the bowel.

(6) *Subnormal temperature* usually persists throughout, unless inflammation or other complications arise.

(7) *Thirst* is pronounced.

(8) *Distention of the abdomen* very quickly follows the *flaccidity* which marked the onset of the condition.

(9) *Embarrassment of respiration and heart* action follows as a result of the abdominal distention.

(10) *Indicanuria* marks acute cases in which the small bowel is involved. The amount of indican may vary from the normal 5 to 20 milligrams to from 100 to 150 milligrams.*

Death supervenes, in acute intestinal obstruction which is not promptly relieved, in from a few hours to a few days. Cases of acute obstruction have been reported in which the patient lived for twenty-one days. The average duration, however, is about six days. The causes of death are generally considered to be gangrene of the bowel in the affected portion, peritonitis, and toxemia.

* According to Barnard[4] the large bowel is not necessarily excluded as the distention may have spread into the small intestine.

Extensive experiments have been conducted for the purpose of determining the cause or causes of death in acute intestinal obstruction, but as yet they have led to no uniformity of opinion.

Chronic Intestinal Obstruction.—The symptoms of chronic intestinal obstruction vary according to the cause, to the degree, and to the location of the obstruction. The symptoms of which the patient complains may range from those of "chronic indigestion" through those which mark the beginning stage of chronic intestinal stasis, to the more pronounced stages of stasis, and on to those of such severity that the case bids fair to eventuate in one of acute obstruction.

In a general way it may be said that chronic intestinal obstruction is characterized by the symptoms of acute obstruction only in less marked degree. The obstruction, of course, is incomplete; the pain comes on more gradually, is less severe, but is intermittent and "colicky" as in the acute stage; the vomiting comes on later, generally only after taking food, and is seldom stercoraceous; the collapse is slight, the temperature normal or slightly below normal in severe cases; the abdomen is distended; in some cases, as in stasis, there is abdominal tenderness to pressure; constipation is less marked, and generally alternates with diarrhea. In some cases, as in advanced chronic intestinal stasis, there may be respiratory and circulatory disturbances. The clinical picture of chronic intestinal stasis is more conveniently given under the head of treatment.

Diagnosis.—The diagnosis of intestinal obstruction is (1) *general*, (2) *differential*.

General Diagnosis.—The general diagnosis of obstruction is made from the symptoms, and has for its primary object the establishment of the existence of *interference with the passage of intestinal contents*. Secondarily, its object is the determination of the *degree* of obstruction, its *location*, and its *cause*. In other words, the general diagnosis, or the discovery of obstruction in some degree, immediately calls for the differential diagnosis.

Differential Diagnosis.—By the differential diagnosis, in turn, one must determine (1) whether the obstruction is acute or chronic; (2) the cause. The differential diagnosis must also determine absolutely that the symptoms are not due to conditions similar to intestinal obstruction, for example, external hernia (which is usually considered as a pathological condition in itself, apart from intestinal obstruction), pancreatitis, peritonitis, embolism and thrombosis of the mesenteric vessels, etc.

In acute obstruction, where the interference with the passage of the contents of the bowel is complete, or so nearly so that the call for laparotomy is urgent, one must depend upon the symptomatology, and upon exploratory laparotomy, by the latter the cause being determined and the treatment suggested. It is manifestly impossible to resort to radiographic or fluoroscopic examination, to lavage, and to the numerous special diagnostic measures which may be employed in chronic cases. Nor are these necessary. Sometimes, especially in reflex paralytic obstruction and in obstruction due to spastic stricture, the giving of an anesthetic, preparatory to laparotomy, will cause free evacuation of the obstructed bowel, thus differentiating between obstruction due to these causes and that which is due to volvulus, acute intussusception, internal hernia, etc. Babcock[5] has reported cases in which the administration of stovain by spinal injection, preparatory to operating for acute intestinal obstruction, has been promptly followed by complete evacuation of the bowel and relief of the obstruction.

In chronic obstruction, however, the differential diagnosis calls for the employment of various methods and tests before resorting to exploratory laparotomy. In many cases the diagnosis is established by the institution of certain methods of treatment. In mild cases, for example, of chronic intestinal stasis, due to various visceroptoses, or caused by intraabdominal bands and resulting kinks in the intestine, the interference with the passage of the contents of the canal may be corrected by the administration of Russian mineral oil, by regulating the diet, giving exercises, correcting posture, properly adjusting abdominal supports, and by instituting the various medicinal and hygienic measures which seem to be applicable to the individual case. The disappearance of the symptoms is presumptive evidence of the correctness of the tentative diagnosis. In these and in the more severe cases of chronic intestinal stasis, however, it is advisable to resort to radiographic and fluoroscopic examination, with bismuth, when possible, in order to substantiate the clinical differential diagnosis.

The guides to differential diagnosis which may be utilized in general are (1) *general history;* (2) *general symptomatology of intestinal obstruction;* (3) *age* (an important guide in infants and children); (4) *special signs*, such as flatulence, distention, tumors, contractions of large and small bowel, as seen through the abdominal wall or as felt upon palpation, findings upon rectal examination, indicanuria.

The differential diagnosis of intestinal obstruction from other conditions giving rise to similar symptoms (external hernia, peritonitis, pancreatitis, etc.), need not be discussed here. The diagnosis may be made by exclusion, beginning with these similar conditions and working toward intestinal obstruction, as well as by beginning with intestinal obstruction and working toward the other conditions.

In chronic cases of severe degree, if the differential diagnosis is not established by the methods mentioned, or by the application of certain therapeutic measures which look to the determination of the diagnosis, and if the symptoms persist, particularly if they are increasing in severity, exploratory laparotomy is indicated.

Treatment of Acute Intestinal Obstruction.—In cases of acute intestinal obstruction no time should be lost in attempts at palliation. Exploratory laparotomy should be performed as soon as the diagnosis of acute obstruction is made. If, perchance, the condition is the result of spastic or reflex paresis or paralysis, the anesthetic administered preliminary to the laparotomy may bring about a thorough emptying of the bowel, thus establishing the differential diagnosis with reference to the etiology. In this event operative procedure is abandoned.

If, however, the administration of the anesthetic is not followed by the evacuation of the bowel, the abdomen is opened, and the abdominal, peritoneal, and pelvic cavities explored. The treatment applied depends, of course, upon what is discovered. It is essentially surgical.

Space does not permit the full discussion of the surgical treatment of acute intestinal obstruction as produced by the various etiological factors. A few words concerning each will suffice.

The treatment is given in sequence of the causes enumerated above, with the exception of certain etiological factors, notably, foreign bodies, which are classed under the head of chronic obstruction, but which, as a rule, do not demand surgical attention until the acute stage is superimposed upon the chronic condition. Cases of this class, from the point of treatment, are considered as acute.

Congenital Atresia.—Acute intestinal obstruction may be noted at birth, in which event the cause may be sought in congenital atresia of the alimentary canal at some point. The points of predilection are the esophagus (which is not under discussion here), at the pyloric outlet, in the rectum, or at the anus.

Congenital pyloric stenosis may be remedied by gastroenterostomy or by one of the newer methods

of pyloric repair, such, for example, as that devised by Keefe,[14] of Rhode Island.

Atresia of the anus, or of the rectum within an inch or two of the anus, may be very easily rectified by plastic operation. When the occlusion occurs higher up in the rectum enterostomy is indicated—from the surgical point of view. From the humanitarian point of view, however, euthanasia is justifiable in these cases. To condemn an individual to a life complicated by a perpetual gastroenterostomy cannot be harmonized with higher ethics, however much medico-legal considerations may demand it.

Internal Hernia.—True internal hernia, according to the consensus of surgical opinion, is an exceedingly rare condition. Thirteen cases of true internal hernia were admitted to the surgical wards of the London Hospital in thirteen years, according to Barnard,[4] out of 669 cases of intestinal obstruction. Of these cases three were diaphragmatic, leaving ten of the class which come under discussion here.

Despite the rarity of the condition, it is important in each case of acute obstruction to thoroughly investigate all hernial apertures.

True internal hernia may occur at the following points:

(1) Through the foramen of Winslow, into the lesser peritoneal sac.

(2) Into the *fossa duodenojejunalis* (Trietz's hernia). This may be right-sided, into the fossa behind the duodenojejunal junction, formed by a fold of peritoneum; or left-sided, situated in the mesocolon, "bounded by the vascular arch formed by the left colic artery and the inferior mesenteric vein as they come in contact and cross each other.[5] This is important, inasmuch as it is often impossible, as has been pointed out by these authors, to enlarge the opening by cutting. The neck of the sac can be enlarged with safety only by being divided in a downward direction.

(3) Into the *intersigmoid fossa.* This fossa is formed by the layers of the sigmoid mesocolon, and is situated at about the bifurcation of the iliac vessels and to the left side of the sigmoid mesocolon.[6] This is a very rare form of internal hernia.

(4) *Pericecal* (ileocecal, ileocolic, and subcecal) hernia. According to Moynihan,[7] a very exhaustive search of the literature failed to reveal any recorded cases of hernial protrusions into the ileocolic or the accessory ileocolic fossæ. These fossæ, he holds, are of anatomical interest only. They are generally considered, however, as possibilities to be borne in mind, for which reason they are recorded here.

The possibilities of occurrence of internal herniæ are given by Moynihan as follows:

(1) Duodenal, left-sided and right-sided.
(2) Mesocolic.
(3) Into the infraduodenal fossa.
(4) Pericecal: into the ileocolic fossa; into the accessory ileocolic fossa; into the ileoappendicular fossa.
(5) Into the retrocolic fossa.
(6) Into the fossa of Hartmann (ileocecalis infima).
(7) Into the fossa iliacosubfascialis (Biesiadeck).
(8) Retroperitoneal of the vermiform process.
(9) Into the intersigmoid fossa.
(10) Into the lesser peritoneal sac.
(11) Into the foramen of Winslow.
(12) Into the lesser peritoneal sac through an abnormal aperture.

Whenever internal hernia occurs strangulation of the gut may result, with consequent stoppage of the onflow of the contents of the bowel, and peritonitis, sometimes within twenty-four hours, or, as is sometimes the case, within a week or two.

The treatment of internal hernia consists in the reduction of the hernia by enlarging the aperture in the omentum or mesentery in which the herniated gut is incarcerated, and then sewing up the slit. In some forms of internal hernia it is practically impossible to reduce the hernia without fatal results. In such cases enterostomy is indicated.

Strangulation by Bands.—Closely allied to internal hernia as a cause of acute intestinal obstruction is strangulation by bands through mesenteric or omental apertures. The obstructing bands chiefly to be noted are *solitary peritoneal bands, omental bands,* and *diverticula* (Meckel's and others). The appendix, the Fallopian tubes, the pedicle of an ovarian tumor, and various other intraabdominal structures may be so placed as to constrict the intestine to the degree of causing acute obstruction. The same may be said of postoperative bands, which have followed operations such as uterine suspension.

The most acute cases, according to some observers, result from these strangulating bands. The small intestine, particularly the terminal ileum, is the part most frequently involved.

The treatment of acute intestinal obstruction caused by bands consists in the division of these structures and the reduction of the strangulated bowel. If the portion involved has become gangrenous, it must be exsected if the condition of the patient warrants it. Otherwise the gangrenous portion should be placed outside the abdomen and a temporary fistula formed. If the strangulation has occurred through an aperture in the mesentery or omentum, whether this opening is congenital or accidental, the treatment consists in enlarging the aperture and releasing the gut. The normal size of the aperture is always restored if possible, and all raw surfaces covered over.

Volvulus.—Volvulus of the intestine results from the twisting or axial rotation of the gut, (1) around its longitudinal axis; (2) around its mesenteric axis; (3) one coil around another.

Volvulus may occur in the small intestine, in the cecum, at the sigmoid flexure, and in connection with mesenteric cysts and tumors.

The most common variety is volvulus of the sigmoid flexure.* Such a case is represented in Fig. 3483. The patient (J. W. N.), male, aged forty-six, physician, had had chronic constipation for a number of years.

FIG. 3483.—J. W. N.—Volvulus of the Sigmoid.

While cranking his automobile, in August, 1914, he suddenly developed acute intestinal obstruction. Operation was performed at once (August 13, 1914), when it was found that the sigmoid was twisted and obstructed by bands which anchored the redundant sigmoid tightly to the sacrum, causing a volvulus.

In connection with volvulus of the sigmoid Lane[8] says: "This obstruction may become complete because of a rotation of the loop upon the base formed by its approximated extremities, or because of an excessive sagging of the lower part of the loop exerting

* The term *sigmoid* is retained merely because it is still so largely employed. The term *pelvic colon*, as exclusively used by the most modern anatomists, is preferable.

a drag on its lower limit sufficient to occlude its lumen. A certain amount of obstruction to the passage of feces from the sigmoid into the rectum is always present. It is in these cases that complete intestinal obstruction may occur, owing to the twisting or rotation of the overloaded and elongated loop becoming sufficient to prevent the passage of any material from the sigmoid loop into the bowel beyond. It will thus be seen that the so-called volvulus of the sigmoid (occurring spontaneously and not as an after-effect of an abdominal operation) is a phase of a condition of partial obstruction of long standing, the loop being habitually overdistended with intestinal contents, and the passage of feces from it being chronically interfered with. I do not think that acute volvulus of a perfectly normal sigmoid can occur spontaneously. The same remarks apply equally to volvulus of the cecum." The case cited above bears out this contention.

The treatment of volvulus consists essentially in the straightening of the twist in the gut. In order to accomplish this it is necessary first to evacuate the distended coil of intestine. All manipulations must be made carefully, to prevent rupture of the distended portion. After the volvulous portion has been evacuated, and the incision through which this was accomplished closed, careful search is made for the volvulus, and to determine its exact nature. It is then dealt with according to requirements of the individual case. All adhesions which hold the intestine in its twisted position are separated, with finger or instrument.

In order to prevent recurrence of the twist of the pelvic colon it may be necessary to insert a drainage tube per rectum, leaving it *in situ* for forty-eight hours. The tube is inserted well up to the sigmoid. In some cases it may be necessary to fix a tube into the opening made for the evacuation of the distended loop, thus making a temporary enterostomy.

Sometimes it is impossible to untwist the volvulus, or the affected portion of the gut may be gangrenous. Resection is then the only alternative. This may be performed by the method employed by Lane,[9] or by whatever method the operator may prefer.

Intussusception (Acute).—Intussusception is the passing or invagination of one portion of the intestine into another, generally the upper passing into the lower. This is one of the commonest forms of acute intestinal obstruction, especially in children. Barring congenital atresia or other malformation, intussusception is practically the only form of acute obstruction met with in infants. About one-third of all cases of intestinal obstruction come within this category.

Intussusception is supposed to occur most frequently at the ileocecal valve. It may be (1) ileocecal (invagination of the end of the ileum into the cecum through the ileocecal valve); (2) enteric (invagination of some part of the small intestine—most frequently the jejunum—into the part below; (3) colic (invagination of one part of the large bowel into another; (4) ileocolic (invagination of the ileum through the ileocecal valve into the colon).

The treatment of acute intussusception, regardless of the point of occurrence, is surgical. Upon opening the abdomen the gut is examined carefully, *in situ*, to determine whether the tumor is *reducible*, *irreducible*, or *gangrenous*.

If the tumor is reducible it is promptly subjected to this treatment by whatever method the surgeon may prefer. The method employed by Moynihan has proved satisfactory in the writer's experience.

If the tumor is irreducible (but not gangrenous) excision of the affected portion of the gut is necessary, the selection of technique being a matter of preference. In infants excision is considered by some surgeons as too severe. A method satisfactorily employed by some has for its object the relief of the obstruction by a lateral anastomosis of the bowel above and below the obstruction. The advantages of this operation are offset by the danger of gangrene of the affected portion of the gut, and fatal peritonitis.

Paralysis ("Adynamic Ileus").—Paralysis of the intestine causing obstruction may be reflex, toxic, or traumatic. Some authors consider the subject under the head of acute obstruction, others, chronic. However considered, it may, and often does, demand prompt surgical intervention. Electrical enemata and irrigation of the colon may be employed successfully in some cases, and, as we have already noted, the administration of the anesthetic preliminary to performing laparotomy may restore the muscular tonus of the bowel sufficiently to overcome the obstruction. If these fail, however, prompt surgical treatment is demanded. Sometimes the obstruction is relieved immediately upon opening the abdomen. Whether this is the result of a certain tissue shock, of the manipulation of the gut, or of the mere exposure to the air, as some have suggested, has not been determined. Should none of these events transpire, and should there be considerable distention, with other urgent symptoms, enterostomy is indicated.

Spastic Stricture.—What has been said with reference to the treatment of paralytic obstruction is applicable to the form which results from spastic strictures, as encountered chiefly in neurasthenic individuals.

Foreign Bodies (Sudden Impaction by).—The points at which obstruction is most likely to be caused by a foreign body are (1) the pyloric sphincter; (2) the ileocecal sphincter; (3) the anus. The cecum and appendix may give lodgment to foreign bodies, causing symptoms which call for prompt surgical intervention. Diverticula may be formed at any point by the foreign body. In this event symptoms of obstruction are not manifest at first, but may arise when the body is increased in size by fecal accumulation. Calculi are generally considered the commonest form of foreign body causing obstruction.

Incision of the intestine and removal of the impediment is the quickest and safest procedure. If sufficient traumatism has been caused by the foreign body to induce gangrene, excision of the affected portion of gut is indicated.

Fig. 3484.—Hair-ball Removed from Stomach of a Seven-year-old Child.

Fig. 3484 shows a hair-ball removed from a female child, aged seven. There was a history of chronic intestinal obstruction, with intermittent attacks of acute obstruction, which were controlled without operation until the last, which occurred in April, 1908. Laparotomy was performed, and a hair-ball was found in the stomach, projecting into the pylorus and completely blocking it off. The ball measured about seven inches in length, and nearly two inches at its widest portion. The smaller end projected into the pylorus.

This case illustrates the fact that chronic obstruction may suddenly become acute. Presumably, the

previous attacks of acute obstruction were caused by the temporary blocking of the pyloric outlet, the attack subsiding when the hair-ball left the pyloric orifice, perhaps being washed out by the fluids taken into the stomach, or perhaps by muscular action. When it had increased in size to such an extent that this was not so easily accomplished, and when it became suddenly impacted, true acute obstruction occurred.

Treatment of Chronic Intestinal Obstruction.—The treatment of chronic intestinal obstruction is as varied as are the causes and the degrees of the condition. Whenever the obstruction is sufficient to be a serious menace to health or life, or when it is markedly progressive in its course, the surgical removal of the obstructing agent is imperative. This is particularly true of severe cases for the additional reason that such cases may at any time become acute.

An example of chronic intestinal obstruction suddenly becoming acute is illustrated in Fig. 3483.

The treatment of the different classes of chronic intestinal obstruction is briefly given according to the causes enumerated.

Extrinsic Causes: Abdominal Tumors.—Sufficient pressure may be exerted upon the bowel to cause a greater or less degree of obstruction, even to the point of complete occlusion. As a rule, however, the tumor of itself produces symptoms which lead to its removal before it has caused complete or acute intestinal obstruction. Such tumors are removed in accordance with the accepted technique for the specific kind of growth.

Adhesions (Cicatricial), *Bands* (Evolutionary, Congenital, or Inflammatory).—The degree of obstruction which results from bands, of whatever origin, may vary from a mild form to that which calls for the most radical surgery, such as colectomy.

This form of obstruction has been described by Sir W. Arbuthnot Lane under the term *chronic intestinal stasis.* He differentiates it from constipation as this is ordinarily understood. The chief point of differentiation rests upon the matter of absorption of the poisonous elements of the alimentary content, or rather of the *residual* part of the content. Lane has repeatedly called attention to the fact that there may be a very marked degree of constipation with very little absorption and practically none of the symptoms of toxemia. In the condition which he calls chronic intestinal stasis, on the other hand, there is always retention of intestinal content, despite a possible diarrhea, absorption of the products of decomposition, and toxemia (or, as some prefer to consider it, "subinfection"), with a characteristic symptomatology which varies with the degree of stasis and of toxemia.

The symptoms of chronic intestinal stasis give such a characteristic picture that they may be detailed apart from those of chronic intestinal obstruction due to causes other than obstructing bands and adhesions.

In a previous communication[10] the following statement was made concerning the causal relationship existing between intestinal obstruction and chronic intestinal stasis: "The symptomatology, diagnosis, and treatment of the various types of acute intestinal obstruction may be said to have long been matters of general knowledge. The existence of chronic intestinal obstruction has also been accepted as a possible contingency. It was left, however, to Mr. Lane to establish the fact that many of the factors concerned in the production of the various types of chronic intestinal obstruction are associated with, or perhaps are dependent upon, an already existent chronic intestinal stasis, and that they are, in reality, end-results of such a condition." If Lane's estimate of the matter be correct, the vicious etiological circle established with the inauguration of chronic intestinal stasis warrants the most careful attention.

The symptomatology of advanced stasis due to bands causing kinks and obstruction of the intestine has been so admirably stated by Chapple[11] that it may be given as formulated by him. He reviewed fifty cases, in which he found the following constant set of symptoms: "(1) Headaches, which were severe and frequent. (2) Attacks of nausea, often followed by retching or actual vomiting. In some cases the vomiting was very frequent indeed and of a severe nature. It was very interesting to note that in several of the cases blood was frequently present in the vomit, and had led very able men to the diagnosis of gastric ulcer, although none such was found at the operation. (3) Loss of appetite was almost constantly present. (4) Loss of weight was present in all cases. (5) Markedly cold hands and feet, which gave an indication of a defective circulation. (6) Mental apathy. This was very definite in most cases. . . . (7) Constipation, which in all was persistent and its previous treatment had failed. One case had gone on several occasions for twenty-eight days without an action of her bowels in spite of treatment. (8) A constant foul taste in the mouth, which was often accompanied by foul breath and carious teeth. The tongue was constantly furred. (9) Attacks of abdominal distention, which were accompanied by discomfort and relieved by eructation or the passage of

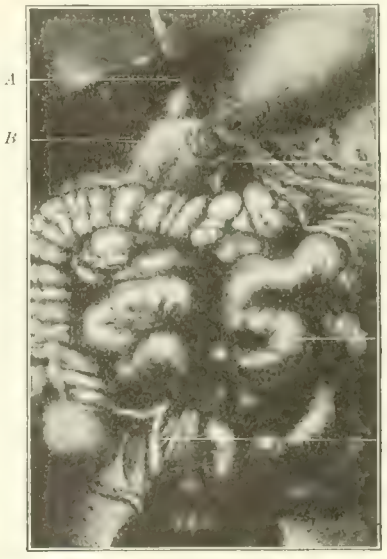

Fig. 3485.—Pyloric Obstruction. *A*, Duodenal diverticulum; *B*, inflammatory mass about 2d portion of the duodenum; *C*, duodenojejunal juncture "kinked." *D*, dilated small intestine above the ileopelvic band; *E*, site of obstruction in terminal ileum.

flatus or an action of the bowels. (10) General muscular pain and a loss of freedom in the movement of the joints."

The above symptomatology, which is characteristic of advanced cases of chronic intestinal stasis, is less marked in milder cases. The treatment employed depends upon the severity of the symptoms.

In beginning cases the treatment is hygienic and medicinal, the object being to forestall the severer degrees of stasis, or obstruction. By the proper care and feeding of infants and young children the conditions which make for stasis in the adult are prevented. The proper care of weak, delicate patients, and those recovering from severe illness, will often present the "static" condition. When the diagnosis of beginning stasis is made, the patient should at once be placed under a dietetic and hygienic regime. Suitable exercises, proper attention to posture, the use

of well-fitted abdominal supports, and the use of suitable medicinal measures, will generally suffice to restore the patient to a normal condition. Russian mineral oil, which acts mechanically, has been found particularly efficacious in these cases.

When the case resists treatment by dietetic, hygienic, and medicinal measures, it becomes necessary to resort to exploratory laparotomy. In many of the milder cases, in addition to the preventive measures, it may be necessary to cut bands, to replace hollow organs, to change angles, and to generally restore the normal status of the drainage system.

In advanced cases, however, more radical surgical intervention is required. The patient may be restored to perfect health by Lane's "short-circuit" operation[9] (ileocolostomy). In other cases this is not sufficient, colectomy being then indicated.

Fig. 3485 represents a case of advanced chronic intestinal stasis, with typical symptomatology.[12] The patient (C. C.), male, aged forty-nine, was operated upon December 25, 1913. The conditions found, as shown in the picture, were: dilatation of the stomach; almost complete pyloric stenosis; diverticulum of the duodenum, with a mass of inflammation about it; marked duodenojejunal kink; adhesions between neck of gall-bladder and duodenum; pronounced ileal stasis; marked ileopelvic bands; some enlarged glands about the pylorus and back of the liver. The treatment consisted in the following: 1. gastroenterostomy; 2. ileal band cut transversely and sutured longitudinally; 3. appendix, which was normal, removed; 4. small fibroid of right lobe of liver at free margin excised, liver sutured.

Fig. 3486.—Malignant Stricture of Transverse Colon

Intrinsic Causes.—(1) Involving the gut itself. (2) Occurring within the lumen of the gut.

Intussusception (Chronic).—Chronic intussusception calls for laparotomy and reduction of the intussusception, just as in acute cases. Some clinicians prefer to employ enemata first, while others consider it a needless waste of time.

Chronic intussusception sometimes undergoes spontaneous cure; rarely it is spontaneously eliminated; it may become acute; or perforation may take place. In any event the treatment is surgical reduction, the urgency of the treatment depending upon the severity of the symptoms and the age of the patient. In infants and young children the call for immediate laparotomy is urgent.

Strictures causing obstruction may be malignant, cicatricial (resulting from ulceration or injury), or they may be congenital. A large proportion of cases of chronic intestinal obstruction result from strictures of one origin or another, tuberculosis and malignancy probably being in the majority.

Fig. 3486 represents a case of malignant stricture of the transverse colon at the site of an omental band extending from the stomach across the transverse colon, and adherent to the pelvic colon. The patient (J. T.), female, was operated upon at the Ossining

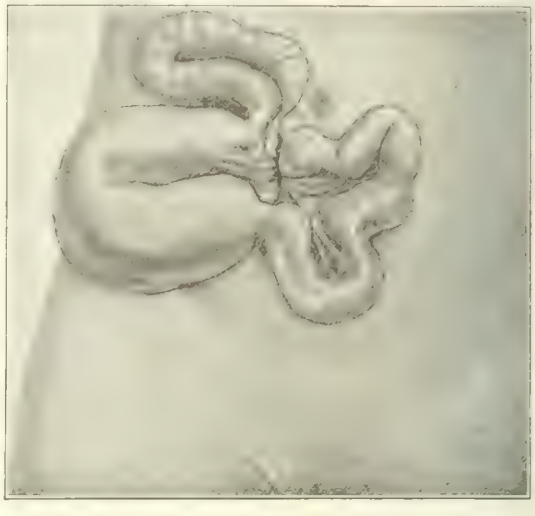

Fig. 3487.—Multiple Tuberculous Strictures.

Hospital. She had had long-standing chronic obstruction which became almost acute. There was persistent vomiting and the patient was in a very poor general condition. Radical operation was not advisable, so that ileocolostomy ("short-circuit") was performed. The malignant condition was left for subsequent operation, but the patient has felt so well since the short-circuit operation that she has refused further surgical intervention.

Fig. 3487 represents a case of multiple strictures of tuberculous origin, with chronic intestinal obstruction.[13] Fig. 3488 gives a diagrammatic representation of the intestine showing the relative position and size of the strictures.

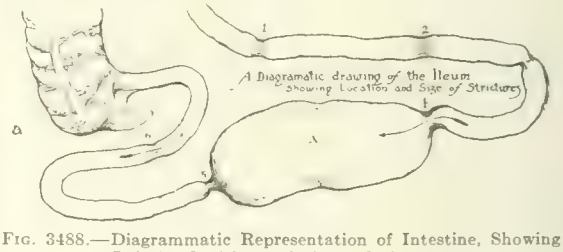

Fig. 3488.—Diagrammatic Representation of Intestine, Showing Relative Position and Size of Strictures.

Treatment in this case consisted in making a lateral anastomosis of the portion above and below the most marked strictures, with a longitudinal incision and transverse suture of the third point of greatest constriction. The three lesser constrictions were not considered sufficiently marked to warrant surgical interference.

Foreign bodies causing chronic intestinal obstruction, as previously stated, do not generally come to the surgeon's attention until the acute stage of obstruction has been reached. In the interim other treatment is generally employed by the internist, according to the history and general examination of the patient.

Polypi, cysts, malignant and other tumors involving the wall of the gut may project into the lumen and act as foreign bodies, giving rise to chronic intestinal obstruction, varying in degree according to the size of the growth.

Fig. 3489 represents a cyst of the mesentery which involved the wall of the intestine down to the mucosa. It was situated at the mesenteric border of the ileum,

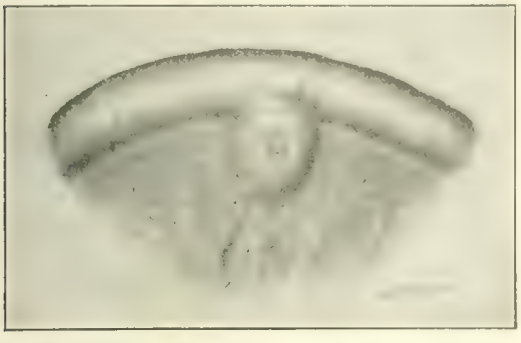

Fig. 3489.—Cyst of Mesentery, Involving Wall of Gut Down to Mucosa.

about twenty-four inches from the ileocecal valve, and was of the size of a hen's egg.

Treatment in such cases consists in the removal of the obstructing growth, the technique depending upon the nature, size, and situation of the tumor.

William Seaman Bainbridge.

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Intestinal Surgery.—Instruments and Suture Material.—The instruments necessary for intestinal surgery are comparatively few and simple. Although there exists an abundance of complicated mechanical devices for suturing the intestines, nothing serves the purpose better than a thread, a straight or curved needle, a needle-holder, and the trained hand of the surgeon.

The needle may be a straight milliner's needle No. 3 or a needle with a full curve that can be easily manipulated with or without a holder. Moynihan's curved needle as modified by Scudder serves all purposes. Whether a straight or curved needle is used can be left to the taste of the operator. A straight needle has the advantage of being easily handled by the operator and can therefore be used with greater speed, but it is occasionally found awkward in difficult stitches. The author himself prefers the curved needle manipulated with the aid of a needle holder.

In intestinal surgery it is essential to protect the peritoneal cavity from being soiled by the intestinal contents. Therefore we strive to do all manipulation on the gut outside of the peritoneal cavity. To this end the part of the intestine is carefully isolated and the abdominal cavity is walled off and protected by large gauze pads which are secured by clamps in order not to be lost.

The best suture material for intestinal work is fine silk, either black or white or Pagenstecher celluloid linen thread No. 1. The latter has some advantages over silk. The hard surfaces of the linen thread,

impregnated with celloidin, resists the penetration of bacteria, it does not lose its hard consistency when soaked in water and, in handling, does not stick to the fingers or to the sheets.

After repeated boiling celloidin thread becomes friable and splits longitudinally, but at least three sterilizations can be done with safety.

Different Methods of Suture.—There are certain rules essential to success in the execution of an intestinal suture which must be followed.

Our main endeavor must be to bring the serous coats of the intestine into close apposition. This surface

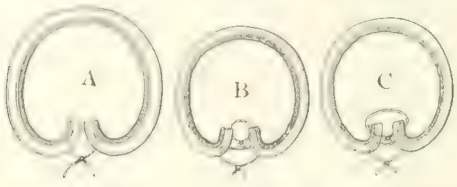


Fig. 3490.—Intestinal Sutures. *A*, Lembert. *B*, Czerny-Lembert. *C*, Lembert-Albert.

has the property of rapid and firm agglutination. Joubert (1824) was the first to recognize this principle and shortly after him Lembert described his classical suture (1826) that is still used to-day. All later suture methods rest upon this. A good many more or less complicated sutures have been invented and described. I shall, however, confine myself to those that are simple and rapid in execution and have stood the test of long experience.

Lembert Suture.—In the original Lembert suture the needle enters the serous coat of the intestine about five millimeters from the edge of the wound, takes in the muscular coat and the subserous coat and emerges from the serous coat about one millimeter from the wound. Then the needle is made to enter at a point one millimeter from the opposite side of the wound to emerge five millimeters from the wound edges. (Fig. 3490, A.)

This simple Lembert suture brings the peritoneal surfaces into broad apposition, but, in as much as it does not take in the mucosa, it does not give

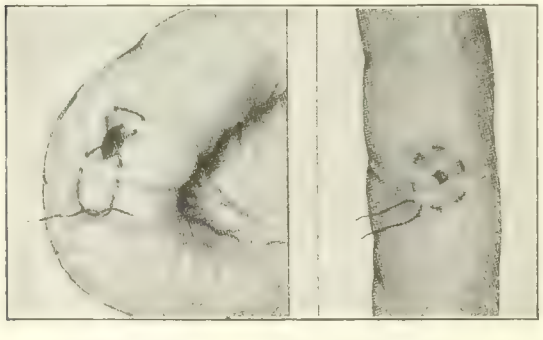


Fig. 3491.—Tuvara Cross-stitch Suture

enough protection against leakage and therefore a second inner suture is added in order to bring the mucosa into close apposition. Czerny added a seromuscular suture and Albert used an inner suture going through all the coats. (Fig. 3490, B and C.) Some surgeons use a separate catgut suture for the mucosa, but this is not necessary, except in especially weak places. The intestinal suture may be an interrupted suture or a running suture. The running suture has the advantage of speed, but, if not drawn tight with an even pull, the suture may loosen at one spot and thereby jeopardize its security, or one stitch drawn too tight, may cut through and open the door for infection. The intervals between the individual stitches can be best gauged by the thickness of the wall of the intestine. In intestinal sutures, two to four millimeters

Fig. 3492.—Closing a Wound at Right Angles to the Longitudinal Axis.

and in stomach sutures three to five millimeters, would constitute about the average distance.

In order to close small wounds of the intestine, a tobacco-pouch suture is frequently useful, if the hole is small and there is no danger of narrowing the lumen

Fig. 3493.—Halsted Mattress Suture

of the gut. After the suture is tied it is strengthened by a Lembert suture. Another very good method is one described by Tuvara, which consists of a cross-stitch. (Fig. 3491.) If the wound in the intestine is of such an extent that there is fear of narrowing of the

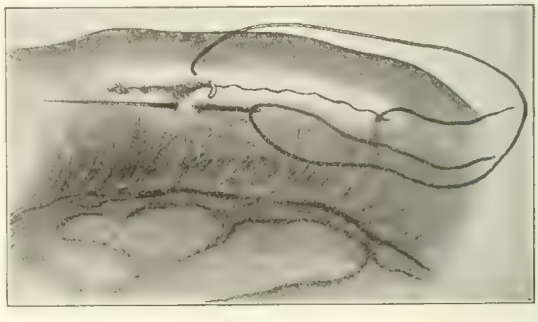


Fig. 3494.—Cushing's Right-angle Continuous Suture.

lumen, it is better to sew it up at right angles to the longitudinal axis of the gut as shown in Fig. 3492.

Other sutures that are used a good deal are Halsted's mattress-stitch (Fig. 3493) and Cushing's right-angle continuous stitch (Fig. 3494).

Knowledge and practice with these methods will enable the surgeon to cope successfully with the problems of intestinal surgery. It is a good plan for the young surgeon to practise any one of these diligently and become an adept in its use; he will soon discard all others so far as his personal work is concerned.

Operations upon the Intestine.—*Enterostomy.*—The purpose of this operation is to establish a communication of the lumen of the intestine with the outer world. The reasons for such a procedure may be threefold. Firstly, we may desire to use the stoma for purposes of nutrition (duodenostomy, jejunostomy); secondly, for the purpose of establishing an artificial anus (preternatural anus, fistula stercoralis), or thirdly, we may use it for medication (appendicostomy).

Duodenostomy, Jejunostomy.—Duodenostomy is only possible in the upper two-thirds of the duodenum, after it has been mobilized. It is rarely indicated and its use is limited.

Jejunostomy has its indications and is of value in cases of malignant disease of the stomach, where the growth has invaded the anterior wall to such an extent that no room is left for a gastrostomy, or in cases in which the stomach has shrunken so much that it cannot be brought up against the anterior abdominal wall. As a temporary fistula, jejunostomy is indicated in severe cases of acid burn of the esophagus and stomach and in severe cases of ulcer of the stomach in which it is desirable to put the stomach at rest.

As this fistula is established for purposes of nutrition, it is important that no contents regurgitate and

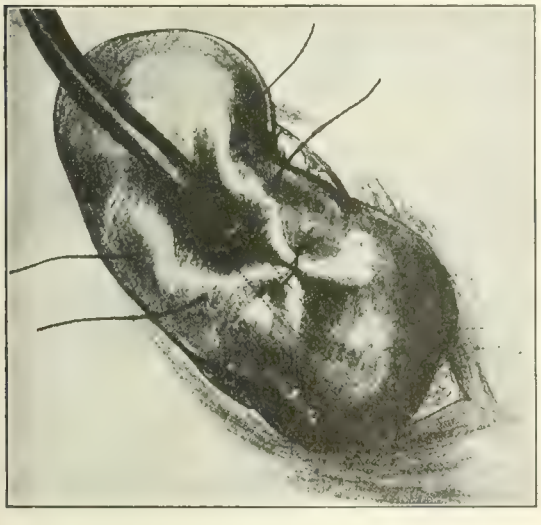


Fig. 3495.—Temporary Jejunostomy.

it must be so constructed that it can be closed easily, if it is intended as a temporary means. Three methods are in existence:

Method of von Eiselsberg-Witzel.—Median laparotomy or left rectus muscle incision. The jejunum is looked for and found by reflecting the omentum with transverse colon and stomach upward. In doing this, the fossa duodenojejunalis will be exposed and the jejunum easily detected. A loop is selected about twenty to thirty centimeters below the fixed portion. After isolating the same from the peritoneal cavity by gauze pads, a small hole is made at its summit, just large enough to admit a soft catheter (18–20 Fr.). The catheter must be pushed, of course, into the efferent portion of the loop, and is fixed to the bowel by a catgut suture. Figure 3495 shows how the oblique groove around the tube is constructed. The loop of jejunum is then fixed to the peritoneum by a few silk or chromic gut stitches. Care has to be taken not to constrict the lumen of the jejunum as the flow of bile and pancreatic juice from above has to be unobstructed. A single Lembert suture for the groove is sufficient. If it is desired to close the fistula, removal of the catheter suffices, the fistula then closing spontaneously.

Method of Mayo-Robson.—This method is a little more complicated than the one just described. In this operation an excluded loop of the jejunum is brought to the surface for the insertion of the tube. Mayo-Robson (Trans. Royal Med.-Chir. Society, 1905) describes the operation as follows:

"The operation I have performed, which I believe is new, consists in taking a loop of the beginning of the jejunum just sufficiently long to reach the surface without tension. The two arms of the loop are short-circuited about three or four inches from the surface, the short-circuiting being done either by means of sutures around a decalcified bone bobbin or by sutures alone. Personally I prefer the former.

"A small incision is then made into the top of the loop just large enough to admit a No. 12 Jaques catheter, which is inserted and passed for three inches down the distal arm of the loop. This is fixed to the margin of the incision in the gut by a silk or a Pagenstecher suture, and the entrance of the tube into the bowel is further guarded by two purse-string sutures, one over the other. The top of the loop is fixed to the skin by one or two stitches and the wound is closed. The patient can then be fed at once with some peptonized milk and brandy. The whole operation can be done in from fifteen to twenty minutes and with very little viscera exposure.

"Should the patient be too ill to bear the little extra time occupied by the short-circuiting, the tube may be inserted as directed and surrounded by two or three purse-string sutures, a proceeding which can be accomplished in a few minutes. In this case the loop of bowel must not be brought to the skin, but had better be fixed by sutures to the peritoneal margin and aponeurosis, in order to leave part of the lumen of the attached loop within the abdomen for the direct passage outward of the intestinal fluid with the bile and pancreatic secretion." (Fig. 3496, A.)

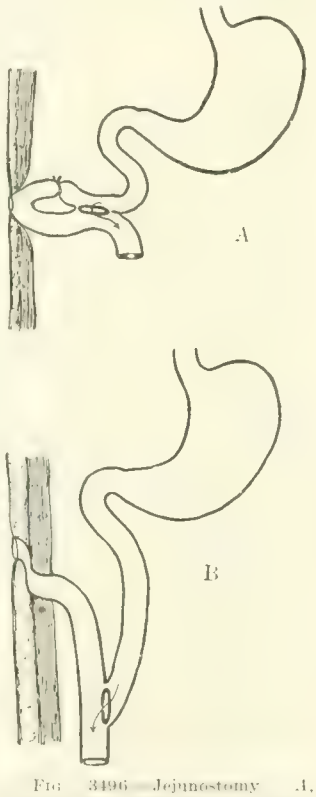


Fig. 3496.—Jejunostomy. *A*, Mayo-Robson's method; *B*, Maydl's method.

Method of Maydl.—This operation is performed after the same principle as the Y-method of gastro-enterostomy of Roux. In the operation the jejunum is completely cut across about thirty centimeters from the duodenojejunal angle. It is advisable to cut the intestine at an oblique angle to its longitudinal axis, in order to give the bowel contents a downward direction. The proximal cut end is then implanted, end-to-side,

into the jejunum about twenty centimeters from its severed end, and the distal portion is brought to the surface. One may twist this end about its longitudinal axis after Gersuny or, by tunneling the skin, lead it out through a separate small incision and thereby bending it in order to avoid regurgitation of bowel contents. This however is not essential. (Fig. 3496, B.)

Enterotomy.—Under certain pathological conditions (peritonitis, intestinal obstruction) it may be imperative to empty the intestines from gas and fecal matter as an emergency procedure. Both of these operations can and should be done under local anesthesia, the condition of the patient in most cases forbidding a general anesthetic.

It is desirable under these circumstances to make the incision into the abdomen in the lateral and lower quadrant, reserving the median incision for the subsequent radical operation. After opening the abdomen, a loop of intestine is carefully isolated and drawn out of the wound. Gauze compresses are then introduced into the abdomen to protect the peritoneal cavity and an incision is made into the bowel opposite its mesenteric border at right angles to its longitudinal axis. After as much as possible of gas and fecal matter have escaped, the incision is carefully closed by a double row of Lembert sutures.

Enterostomy.—In cases in which it is desirable to establish a fistula for draining away the contents of the bowel, an enterostomy is performed.

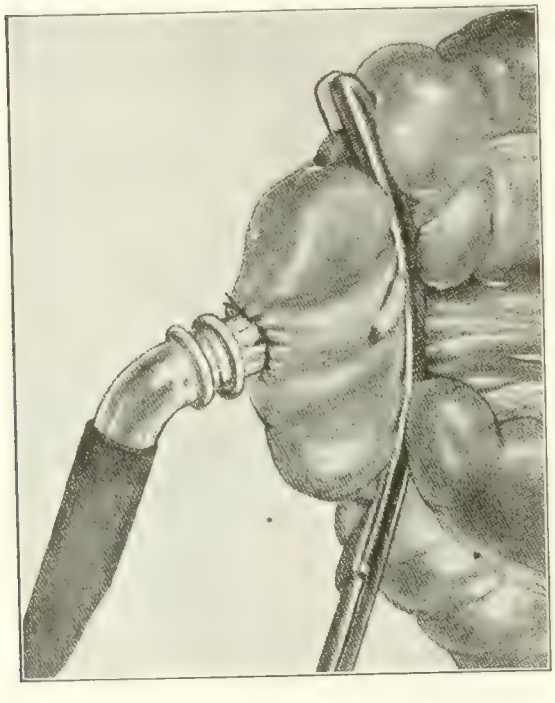


Fig. 3497—Enterostomy with the Paul-Mixter Tube.

The loop of the intestine to be incised is carefully stitched to the peritoneum in order to prevent soiling of the peritoneal cavity. In doing this one has to be very careful not to enter the lumen of the intestine with the needle because the wall of the gut may be extremely thinned out by distention. After this suture has been placed a trocar is thrust into the bowel and a portion of the contents withdrawn. The bowel, being partially emptied, should then be incised and its wall stitched to the skin.

This would constitute the simplest method of enterostomy. It is advisable, if the condition of the patient allows it, to perform enterostomy in two stages. The first stage would comprise the stitching of the bowel to the peritoneum, sewing up the wound close to the exposed loop. After a few days, when the adhesions around the intestine and peritoneum are firm, the bowel is opened with the knife or the Paquelin cautery. This method does away with the danger of peritonitis from leakage. It can, however, not always be used. This simple method of enterostomy has a certain disadvantage. The contents of the bowel, escaping through the fistula, soil and irritate the skin of the patient and can infect the wound with a result-

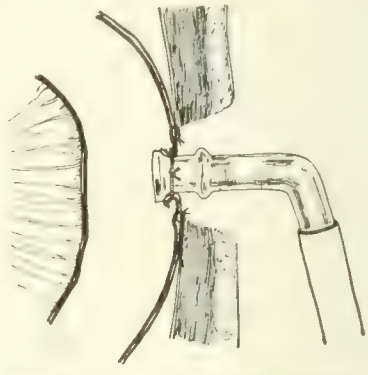


Fig. 3498.—Enterostomy with a Paul-Mixter Tube.

ing phlegmon of the abdomen. In order to do away with these drawbacks the following procedure should be used:

A loop of intestine is isolated, its contents milked out by gentle strokes of the fingers and the loops temporarily clamped with a pair of intestinal clamps.

A small incision is now made into the gut, just large enough to admit a "Paul-Mixter tube" which is fixed by means of a tobacco-pouch suture. The loop of intestine is then stitched to the parietal peritoneum. The glass tube is fixed by dressings, and a rubber-tube leading into a large bottle on the floor is connected with it to syphon off the bowel contents. (Figs. 3497 and 3498.)

After five or six days the sutures around the glass tube will cut through and the tube is then removed. In the mean time protecting granulations will have formed so that the danger of infecting the abdominal incision is done away with.

Payer has constructed a modified Murphy button which he uses in place of the Paul-Mixter tube. It

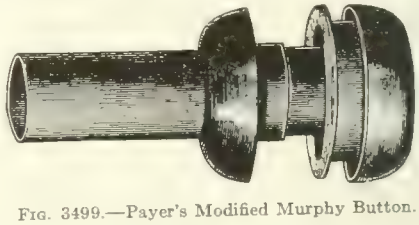


Fig. 3499.—Payer's Modified Murphy Button.

has no side openings and the male portion is lengthened into a tube seven centimeters long which fits into the female part. (Fig. 3499.) The male portion is first fastened into the gut by a tobacco-pouch suture, the loop of intestine is dropped back into the abdomen and the tube is led out by a separate small incision. Now the female portion is slid over it and pushed home in such a fashion that besides the wall of the intestine, peritoneum and fascia transversalis are also caught between the two halves of the button. The laparotomy wound is completely closed. After six to eight days the button comes away and the fistula

has established itself without infecting the abdominal wound.

Appendicostomy.—This operation was first suggested by R. Weir of New York (*Medical Record*, Aug. 9, 1902). It has been used in cases of chronic colitis, especially in those types of the disease which are very resistant to ordinary medical measures: membranous, ulcerative, syphilitic, amebic colitis. It serves a double purpose: (1) to drain the bowel and to clean it from the stagnant infectious material, and (2) to introduce into the bowel medicated solutions in order to act directly upon the pathological process.

It is performed in the following fashion: The cecum is exposed by the usual pararectal incision and brought out of the wound. The appendix is searched for, and adhesions, if present, must be loosened with care in order not to injure the mesentery with its vessels. A separate small opening is made, through which the appendix is pulled out by means of a dressing forceps. It is fastened to the skin by a few sutures, so that one to two centimeters of it project above the skin. The laparotomy incision is closed by a layer suture. After a few days the projecting portion of the appendix is cut off and a small well-oiled Nélaton catheter is introduced into the bowel.

This method is effective and simple in a good many cases where the above enumerated pathological conditions are present. There are, however, a few points, which have to be kept in mind. It can happen that the lumen of the appendix is strictured at some point from its tip to its base, so that after the establishment of the appendicostomy it is impossible to introduce the catheter. It is therefore better to convince oneself about the patency of the appendical lumen by opening it primarily and probing it. In the different chronic inflammatory diseases of the colon very often the appendix is involved. It would, of course, invite disaster if one would use an appendix with ulcerated mucous membrane for any such purpose.

For such cases two methods are at our disposal: (1) The amputation of the appendix and the use of its opening into the cecum as a stoma, or (2) the establishment of a fistula at the cecum after Witzel's method. The latter procedure is preferable. It has been described with the methods of jejunostomy and gastrostomy to which the reader is referred.

Although a large number of good results and cures by these simple methods have been reported, there are undoubtedly stubborn cases of old ulcerative colitis in which drainage and medication alone by appendicostomy does not suffice. The main indication in such severe cases is absolute rest for the large bowel combined with flushing with medicated solutions or sterile salt solution. The writer has in these desperate conditions used a procedure which, although much more complicated, has given gratifying results in a number of cases. The main object of this operation is a complete exclusion of the large bowel.

The abdomen is opened by a pararectal incision. The cecum with the ileocolic junction is exposed and drawn out of the wound. After having protected the peritoneal cavity by a number of gauze pads, the ileum is completely divided between two intestinal clamps. The mesentery of the ileum is split sufficiently to mobilize the proximal end to such an extent that it can easily be pulled out of the wound. In doing this one has to be careful not to injure the branches of the mesenteric vessels.

The distal end is closed by suture and inverted into the cecum. The proximal end of the ileum is now temporarily closed by a silk string and its mucous membrane cauterized with the Paquelin cautery. The ends of the silk string are left long.

The clamp is now removed and the closed end of the ileum pulled out of the wound. A separate incision two centimeters long is now made through the skin a few centimeters mesial to the pararectal incision. By means of a dressing forceps, passed through this skin incision, the silk thread is caught and the proximal end of the ileum pulled through.

By doing this, a kink is produced in the ileum, lying between the rectus muscle below and the skin above. The ileum is now fastened by a few seromuscular sutures to the parietal peritoneum. The appendix is then pulled into the wound and an appendicostomy performed, or, if this organ is found to be diseased, it is amputated and a cecostomy after Witzel is done as described above. The laparotomy wound is now completely closed up to the point where the ileum and cecum or the appendix emerge, as the case may be.

After the closure of the abdomen has been affected, the silk thread, which kept the ileum closed, is removed and a Paul-Mixter tube, connected with a drainage bottle, inserted (Fig. 3500).

After the silk thread has cut through, the Paul-Mixter tube is removed.

All bowel contents will now be emptied through this enterostomy opening. A bandage with a small pad is placed over the enterostomy in such a fashion that

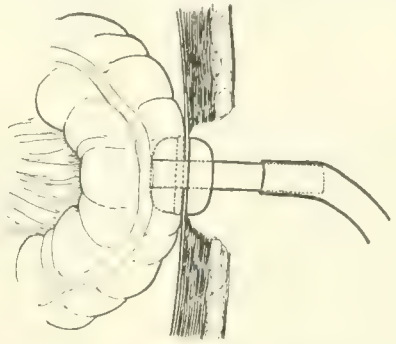


Fig. 3500.—Enterostomy with Payer's Modified Murphy Button.

it will compress the angulated loop of intestine between skin and underlying rectus muscle. In this fashion the patient is able to control the outflow of intestinal contents and to keep himself clean.

This operation effects a complete exclusion of the entire colon, putting it at rest and giving it thereby the best chances for recovery.

The time of treatment extends over several months, it may even last a year. I never close the enterostomy before the washings of the colon have been entirely free from blood, pus, and mucus for at least one month, and the patient free from pain.

It is remarkable how quickly patients will pick up after a short time. Their pain will stop, the absorption of toxic material will cease, thereby improving the appetite. These patients can be fed vigorously on a mixed diet without fear of irritating the excluded bowel.

The closure of the enterostomy is done later by reimplanting the cut end of ileum into the cecum after methods that will be described presently.

Of course this operation should be undertaken only in severe cases, where other methods have failed.

Colostomy and Preternatural Anus.—The foregoing operations have dealt with methods in which the *small* intestine has been used for the establishment of the fistula. It must be remembered, however, that these procedures should only be used in cases of urgency, on account of the physiological importance of the ileum in nutrition. They are indicated in incarcerated and strangulated hernias and in all cases of obstruction of the small intestines where an immediate relief of the distention is imperative.

For the establishment of a *permanent* artificial anus, *the large intestine* is selected, the sigmoid flexure being the part of the colon usually chosen. This operation plays an important rôle as a primary procedure in dealing with rectal carcinomata. There are different methods at our disposal. The aim of every one, however, is to completely divert the fecal stream from the part lying distal to the artificial anus. A method both simple and effective is

Maydl's Operation.—This operation should be done, if possible, in two stages. *First stage:* The abdominal incision is made on the left side, with its center at a line joining the umbilicus to the anterior superior spine. The abdominal muscles are split bluntly in the direction of their fibers. The fibers of the external oblique muscle run in a somewhat oblique direction to the skin incision and the fibers of the internal oblique muscle with the fibers of the transversalis muscle run in a horizontal direction, almost at right angles to the fibers of the external oblique. The blunt separation of these muscular bundles is not always an easy matter and is best effected by beginning the separation of them as near as possible to the outer border of the rectus. This can best be done by using the handle of the knife or a pair of blunt forceps. When the transversalis fascia is reached, two blunt retractors are inserted and the muscles gently held apart.

The fascia transversalis and the peritoneum are now cut in a vertical direction.

It is usually not difficult to find the sigmoid flexure. When the abdomen is opened coils of small intestine are encountered. These are pushed toward the median line with gauze pads. Upon retracting the wound margins, the sigmoid flexure will be readily seen in many cases. If it cannot be brought into view, a simple method of locating it at once, is to sweep the finger along the peritoneum on the outer side of the wound across the iliac fossa until the mesosigmoid is reached.

Sometimes the transverse colon is met with. This can be recognized by the attachment of the large omentum, while the sigmoid is differentiated by its many epiploic appendices and two tæniæ which run along its anterior surface.

The part of the sigmoid selected is of some importance. As a general rule the highest portion should be used. There are two reasons for this. The first is that in a subsequent operation for removal of the rectum in case of carcinoma, the sigmoid flexure can be properly mobilized in order to remove the tumor. The second is that a prolapse of the mucous membrane occurs less frequently, if the highest point of the sigmoid is used.

The sigmoid flexure being found, it is brought out of the wound and a careful pull exerted upon it, until no more bowel will come out, at the same time the lower portion of the gut is returned through the wound into the abdomen.

It is important not to twist the bowel around its long axis, on account of the danger of producing a volvulus. With a pair of blunt forceps a perforation is made through the mesosigmoid between blood-vessels, care being taken not to injure them. Through this opening a piece of gauze or glass-rod is passed so that the loop of sigmoid rides upon it. The afferent and efferent loops are now united below this support by two to three seromuscular sutures.

This step of the operation is a very important one. By these sutures, the two loops are held parallel to each other after the fashion of a double-barreled shot-gun. A high spur is formed, which will prevent the contents of the afferent loop from passing into the efferent one.

The peritoneum is now sewed to the gut with a running catgut suture, closing the peritoneal cavity completely, the muscular incisions being then closed. A few layers of folded gauze are interposed between the ends of the glass rod and the skin, and a dressing applied.

The writer has preferred a glass rod for the support of the intestine, because it can be easily kept clean, which is not the case with a gauze strip, which is quickly soiled by the fecal matter. As there is always a tendency to retraction on the part of the intestine, causing an obliteration of the spur it is advisable to leave the glass rod in place for two weeks until the intestinal loops are firmly attached to the abdominal wall.

Moynihan uses instead of the glass rod, a suture as advised by Ward. This suture passes through all the layers of the abdominal wall, pierces the mesosigmoid at a bloodless spot and emerges at the opposite side, the loop being supported on either side by a piece of rubber tubing. (Fig. 3501.)

In order to keep the bowels from moving and the patient at rest, morphine, 0.015, may be given or tincture of opium gtt. v.–vii. t.i.d. The time at which

Fig. 3501.—Moynihan's Intestinal Support in the Operation for Artificial Anus.

it is necessary to open the bowel varies much in different cases. In cases of acute or subacute obstruction it may be necessary to open the bowel at once and in such a case a Paul-Mixter tube ought to be used, as described above. In chronic or partial obstruction one can wait two, three, or even four days. In these cases one must be guided by the general condition of the patient.

Second Stage.—Opening of the Gut.—The bowel is cut across at right angles to its long axis down to the mesenteric attachment thereby forming two double barrels, shot-gun fashion. This should be done with the cautery knife.

Maydl's operation is a very simple one and can always be done under local anesthesia. For the second stage no anesthesia whatever need be used as the bowel is insensitive.

A very annoying factor about an artificial anus is the impossibility of control over bowel movements. Although a perfect control depends upon the nervous apparatus of a sphincter which cannot be constructed artificially, surgeons have nevertheless tried to help these unfortunates by advising methods by which a certain amount of control is effected. A method giving a complete control does not exist as yet. Madelung and Moynihan have advised an operation in which the sigmoid flexure is divided. The lower end is closed and dropped back and the upper end is brought to the skin by passing it through an anterior and posterior plane of the rectus muscle under a bridge of skin, similar to the method described above under enterostomy, with complete exclusion of the colon. An artificial anus after this method can be easier controlled by a pad (Fig. 3502). Gersuny has tried to effect some control by twisting the end of the bowel about 180–360° thereby causing a mechanical narrowing.

In using the method of Madelung and Moynihan it is well to use the lower part of the sigmoid reservoir

(Wyeth). This operation can only be employed in cases in which the obstruction is not complete and the secretions of the bowel can be emptied through the rectum, otherwise there is danger of the completely excluded loop of intestine being distended by secretion and possibly perforated.

Shoemaker's idea of muscle plastic of the anus could be applied to the preternatural anus. Welke uses crossed muscular bundles of the rectus without cutting them.

Dressing and Management of an Artificial Anus.—After the operation is finished, it is important to protect the wound and the skin from the bowel contents. This protection is effected in those cases in which a Paul-Mixter tube can be used. But this tube will hold at the utmost for about six days. In cases of enterostomy of a high loop of intestine the irritating

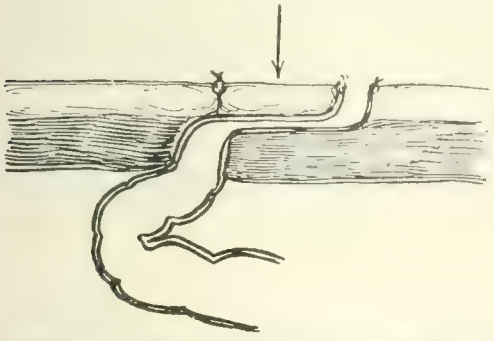


Fig. 3502.—Madelung-Moynihan Method for Artificial Anus; the bowel is closed by pressure in the direction of the arrow.

influence of the liquid ileum contents will have a deleterious influence upon the skin, causing a severe dermatitis with loss of epithelium, so that often the corium is exposed.

A dressing which gives perfect satisfaction is the following: After cleaning the skin thoroughly from blood, a paste, consisting of equal parts of zinc oxide, subnitrate of bismuth, and enough sterile olive oil to make it of a fairly thick consistency, is spread on the skin around the wound. A piece of dental rubber dam, perforated in such a fashion that it closely surrounds the projecting loop of intestine, is fastened with a few strips of adhesive plaster, and over this gauze compresses are laid. This dressing is changed daily and reapplied after cleansing the skin with benzine. By giving the patient a teaspoonful of bismuth subnitrate three to four times a day in milk, the bowel movements are made dry and almost odorless.

Anastomosis.—*Intestinal Anastomosis, Enterostomy.*—This is one of the most important and most frequently used operations the surgeon is called upon to perform on the intestine. The principles involved are the same as in performing enterorrhaphy.

There are various methods in existence: (1) Side-to-side or lateral anastomosis. (2) End-to-side anastomosis. (3) End-to-end anastomosis.

These operations can be done by suture or by mechanical devices of which the Murphy button is the most important one. This latter ingenious contrivance has played an important rôle in intestinal surgery and still has its proper place under certain circumstances. Most surgeons, however, make use of the thread and needle method which, if properly executed, still remains the best. That excellent surgeon, Lejars, says: "In my opinion these ingenious contrivances of the type of the Murphy button have done good service in intestinal surgery, but their time is gone. The natural and simple method to unite two intestinal ends, is the suture."

Enteroanastomosis serves the purpose of reëstablishing an open communication between two loops of intestine. Maisonneuve was the first surgeon to advocate the procedure. It is easily executed and uncomplicated because the mesentery is not interfered with. The different steps of the operation are as follows. The two loops of the intestine are isolated from the abdomen. The peritoneal cavity is carefully walled off by gauze pads and tampons. The two loops to be anastomosed are now arranged side by side. By careful "milking" with the fingers they are emptied of intestinal contents and a curved Doyen's intestinal clamp is put on each loop (Fig. 3503). These clamps which compress the bowel lightly serve the purpose of preventing bowel contents from escaping

Fig. 3503.—Enteroanastomosis with Doyen's Intestinal Clamps.

and of minimizing hemorrhage. An incision about six centimeters long is now made into both loops opposite their mesenteric attachment. This incision divides only the serosa and muscular coat but does not penetrate the mucosa. The posterior Lembert suture is now passed uniting the two margins and muscularis.

In each angle of the incision there is now placed a longitudinal stitch to strengthen the weak point of the suture. These two stitches are important. A Lembert stitch is then placed a little closer to the incision. The ends of these threads are left long and serve as holders. An assistant pulling on this thread holds the line of incision straight. The mucosa is now incised with a Paquelin or a knife, and the anterior Lembert sutures placed, finishing the operation.

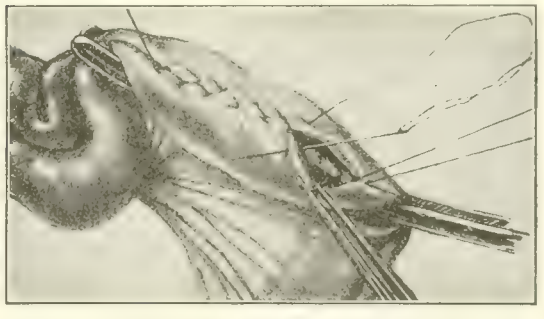


Fig. 3504.—Enteroanastomosis.

This is the simplest method with only one row of interrupted sutures which in the small intestine is perfectly sufficient. A good many surgeons, however, do not like to depend on only one suture, but use two rows of interrupted or continuous sutures. First the posterior suture is placed, the intestine incised through all the coats and the cut walls of the intestine sutured together by going through all the three coats. After these two posterior sutures are finished, the anterior suture is placed. For this suture the author uses the inverting method of Schmieden, which is simple and certain in its effects. The needle travels always from within outward thereby rolling in the wound edges and preventing the mucosa from prolapsing (Figs. 3504, 3505). Over this suture a running Lem-

bert suture is placed. The clamps are now removed and the loops of gut carefully cleaned with a little saline solution and then returned to the abdominal cavity.

Enteroanastomosis by Means of the Murphy Button.—Although the suture with thread and needle is the

Fig. 3505.—Enteroanastomosis

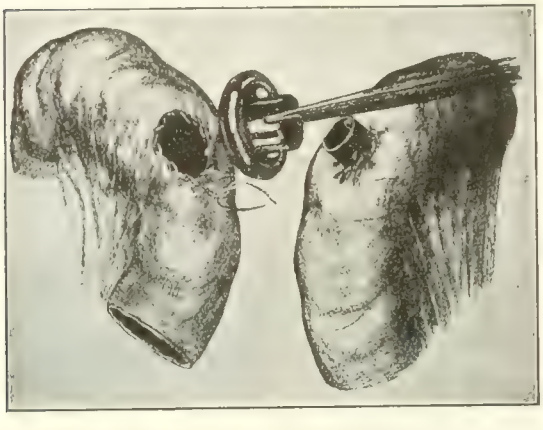


Fig. 3506.—Placing the Murphy Button.

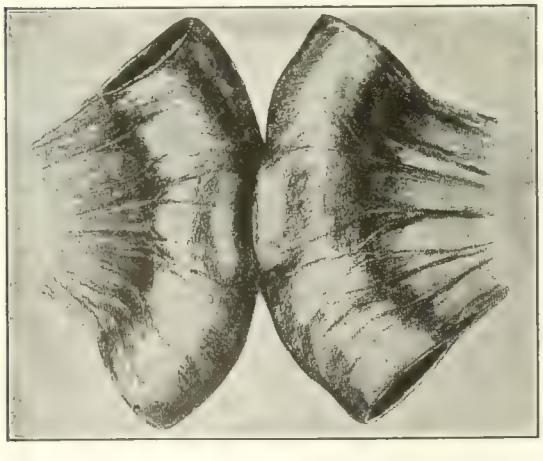


Fig. 3507.—Enteroanastomosis with the Murphy Button.

method of choice, circumstances may arise in which it is desirable to finish the operation as quickly as possible. In these cases the Murphy button is indicated. The button is made of nickel and consists of a male and a female part. By means of a spring and a catch these two halves are pushed together. The method is simple.

After having isolated the two loops as described above, a small incision is made into the intestine just large enough to admit the button.

Before the button is introduced a tobacco-pouch suture is put around the opening which is pulled tight after one-half of the button has been introduced into the bowel. The tobacco-pouch suture is not absolutely necessary if the incision in the bowel is made

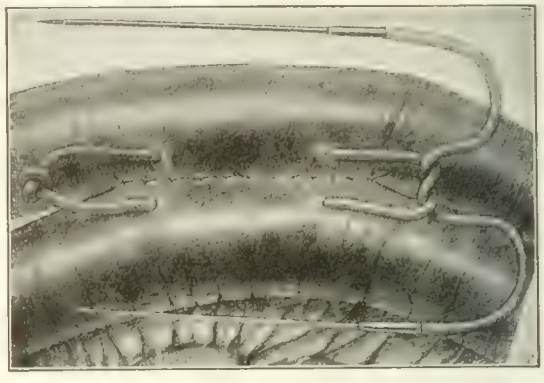


Fig. 3508.—Insertion of the Elastic Ligature for Enteroanastomosis.

so small that the button can just be pushed in by a side twist. Here a stitch on one or both sides suffices to fasten the button. After the two halves of the button are thus secured in the bowel, the button is united by carefully pushing home the two parts. The larger, or male, part should be placed into the afferent loop. Figs. 3506 and 3507 illustrate the method. It is a general rule not to use the Murphy button in anastomosing the large intestine on account of the thinness of its walls and on account of the danger of obstruction of its lumen by hard fecal matter.

A very quick and effective method of doing a lateral anastomosis has been worked out by McGraw. The

Fig. 3509.—Enteroanastomosis by McGraw's Elastic Ligature.

two intestinal loops are joined by a posterior seromuscular suture and then, by means of a stout needle, a round elastic ligature of best rubber is pushed through the intestine (Figs. 3508 and 3509). To prevent including the preliminary continuous stitch in the knot, this suture is depressed with a pair of blunt forceps or the handle of the knife and the ends of the rubber ligature are tied in a half knot over a piece of strong silk. Now the anterior row of seromuscular sutures are laid, closing the whole front of the joint. This procedure has the advantage of being absolutely

aseptic, as the lumen of the gut is not opened to any extent.

The desire to render intestinal anastomosis absolutely aseptic has prompted Joseph to advise an anastomosis clamp (Fig. 3510). Through a small hole in each loop of the intestine the branches of the clamp are thrust, which is then firmly closed. The walls of the gut are hereby crushed and now the place of the anastomosis is carefully sewn over.

After finishing this suture, the small hidden knife is pushed to and fro and the crushed walls are cut through, thus completing the anastomosis. The branches of the clamp are now withdrawn and the two small holes previously made are closed.

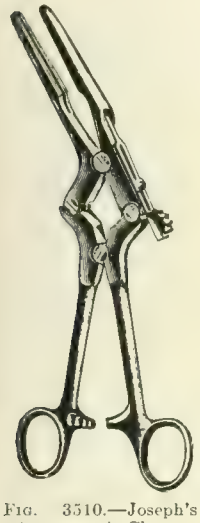


Fig. 3510.—Joseph's Anastomosis Clamp.

End-to-side Anastomosis.—This method of anastomosis is not as widely in use as the lateral anastomosis just described. It finds its application in Maydl's operation of jejunostomy and in implanting the ileum into the colon after resection of the cecum. In this operation, however, many surgeons also prefer the lateral implantation with occlusion of the cut ends of the colon and of the ileum.

An excellent method of the end-to-side implantation of the ileum into the colon has been worked out by Gould. The accompanying drawings taken from Gould's book will explain it better than words (Fig. 3511).

End-to-end Anastomosis and Intestinal Resection.—For the sake of convenience these two operations will be described together as the one usually calls for the other. These operations become frequently necessary in tumors of the intestine, in stricture, in gangrene caused by incarcerated hernias, in invagination, etc.

The operation is done after the same fundamental rules of asepsis as described in the foregoing methods. After the diseased loop is isolated, two clamps are applied to the intestine. In doing this we have to be careful to select a place where the intestine is undoubtedly normal, this being especially important in cases of gangrene or obstruction. If in these cases the intestines are very much distended by gas and intestinal contents, it is well to empty them by an enterostomy. In putting on the clamps, care should be taken to apply them not at right angles to the gut but at an angle of forty-five degrees, the point of both clamps converging toward the mesentery. In this fashion the cut ends of the intestine are wider and the danger of narrowing the lumen by the subsequent suture is done away with.

After the clamps are properly placed, it is best to proceed first with tying the vessels of the mesentery. If the portion of the mesentery is small the latter may be tied parallel to the attachment; when, however, it is necessary to remove a large portion of intestine it is advisable to excise a wedge-shaped piece of the mesentery, because the defect is easier closed and one avoids a puckering and doubling up of the mesentery after suture. This is especially true in cases of very fat mesentery. It is very important to be careful not to tie larger branches of the mesenteric vessels which nourish the anastomosis, or gangrene of the suture line with all its consequences will surely follow.

After the mesentery has been tied, the intestine is cut across, the lumina of the cut end being carefully wiped clean. The clamps are now approximated and the posterior Lembert sutures placed. In order to do this properly one seromuscular suture is placed near the mesenteric border and a second directly opposite. These sutures are left long and held as holders to bring the serous surfaces in line. Kocher starts this suture at the upper angle of the mesentery, thereby at the same time closing the mesenteric cut. The sutures may be interrupted or running.

The next suture consists of the second posterior suture which unites the cut ends of the intestine. The first of these sutures at the mesenteric border is of special importance. At this point lies the weakest spot of the whole suture line.

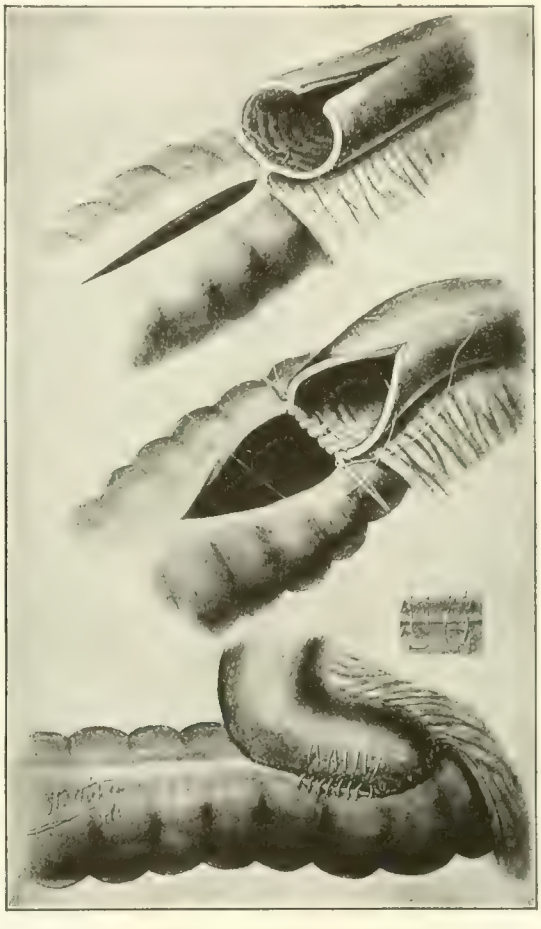


Fig. 3511.—Three Stages of Gould's Method of End-to-side Implantation of the Ileum.

This stitch is started as a mattress suture (Maunsell), as illustrated in Fig. 3512, completely obliterating the triangular intramesenteric space, and is continued as a through-and-through suture bringing the posterior walls of the gut into apposition. This suture can now be continued as the anterior suture. In order to have the mucous membrane fold in, the inverting stitch of Schmieden should be used. Over this suture a running Lembert suture is placed, completing the anastomosis.

A very good method of an end-to-end anastomosis in which perfect asepsis is insured has been described by H. H. Kerr in *Surgery, Gynecology and Obstetrics* (vol. xvii., p. 496) as follows:

Division of the intestinal walls is made between two narrow-bladed crushing clamps, placed first in actual contact and then slightly separated so that there is left between them a narrow crushed area, consisting practically only of serosa and fibrous coat, which may be divided by the knife or cautery.

The basting stitch is a Cushing continuous stitch without knots placed upon the clamped incision with the loops between the stitches crossing over the blades of the clamp. The first bite of the suture applied to either the free or mesenteric border is placed parallel to the axis of the gut; the intervening ones are parallel to the clamp and across the axis of the gut. When the clamp is removed and the stitch at the same time drawn tight, the edges of the incision are automatically inverted and held firmly pressed together in a straight line without any separation of the lips of the opening having occurred. The two incisions, so prepared, are then placed side by side, and are stitched together around the whole circumference of the intestinal tube or of the new operative opening that is to

Fig. 3512.—Obliterating the Intramesenteric Space after Intestinal Resection and prior to End-to-end Anastomosis.

be established. When the last suture has been placed and tied, the basting stitches are cut short and withdrawn, the intestinal canal, or the new anastomotic stoma, then instantly becoming patent. This completes the operation as far as the suture of the intestine is concerned. The lumen has not been opened and it has not been entered by any instrument or other object. The stoma becomes open only with the withdrawal of the basting threads. The steps of the operation are essentially the same whether circular, lateral, or end-to-side anastomosis is done.

The operation so performed calls for no time-consuming maneuvers and no more than ordinary manipulative skill. The basting stitches are as easily and as quickly placed as the purse-string suture used to turn in the stump of the appendix or grasp the Murphy button. Upon the removal of the clamp the stitch is at once drawn tight by a single motion and the incision, securely closed in a straight line, is then ready for suturing without further attention. The turning in of the cut edges which takes place is automatic and never requires the use of an instrument to assist it, as in the case of the purse-string suture.

With the two basting stitches in place, intestinal suture becomes singularly free from its usual difficulties. Only a single assistant is ever needed and even he may be readily dispensed with. The parts to be joined are held in the most convenient position and under perfect control, so that the stitching is done with surprising rapidity and ease.

The troublesome eversion of the mucosa and the vermicular contractions of the muscular coats no longer exist. Approximation of serous surfaces to any desired extent and at a uniform distance from the margins of the incision is assured. The inversion of the cut edges presents a folded wall through which to pass the stitches, making precision in their application, with secure anchorage in the fibrous coat, particularly easy. Handling of intestines is reduced to a minimum. The hand of the operator need scarcely touch them, and those of the assistant not at all.

In end-to-end suturing the small triangular peritoneal defect at the mesenteric border is automatically obliterated by the basting stitch, insuring apposition of serous surfaces at this point.

A striking advantage of the method is seen when the two incisions to be joined happen to be of unequal length. In this case the longer one is simply puckered or "gathered" in upon its basting thread until it corresponds in length with the shorter incision and the sutures are then applied. We have successfully united in this way without the slightest difficulty intestinal incisions, one of which was double the length of the other. This procedure has not been modified materially, though experience has taught us the importance of some of its steps.

No special clamp is necessary for the crushing of the intestinal walls. The writer prefers the ordinary curved Kelly clamp to the one made for the purpose. It is an advantage to place the clamps across the intestine at an angle of forty-five degrees to the long axis of the bowel. This insures a stoma of twice the area of the one made by a transverse division.

Then the amount of tissue to be invaginated and the width of the blades of the crushing clamps are of no moment as the occurrence of obstruction from the formation of a diaphragm is well-nigh impossible. No angulation of the gut occurs after such anastomosis. Pagenstecher thread is advised for the basting stitches and can be most easily applied on a curved French needle. One anastomosing suture of intestinal silk has always been found ample, even in pylorectomy or gastroenterostomy.

Resection of Intestine and Lateral Anastomosis.—In cases in which the lumina of the intestines are unequal,

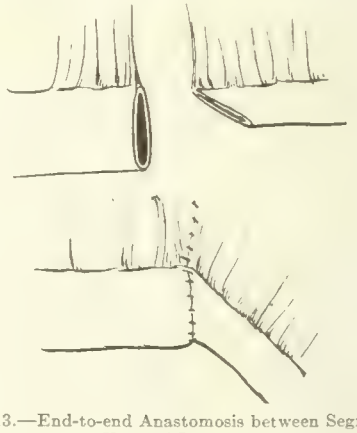
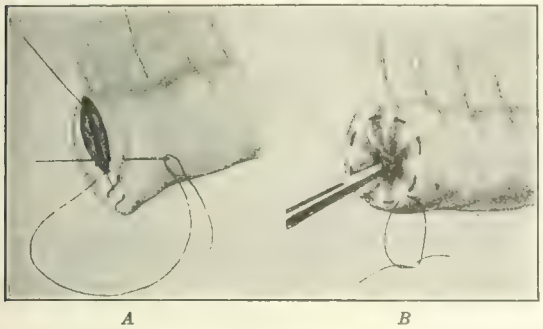


Fig. 3513.—End-to-end Anastomosis between Segments of Unequal Lumina.

an end-to-end anastomosis has certain disadvantages. It is true that even under these conditions an end-to-end anastomosis is feasible by cutting one end of the intestine on the slant to bring the lumina to an equal size. This is illustrated by the accompanying drawings (Fig. 3513).

Most surgeons, however, prefer the lateral anastomosis with closure of both ends. As the method of lateral anastomosis has been described, we shall here consider only the procedure of closing the ends of the intestine. This can be done by two rows of suture (Fig. 3514, A) or better by the powerful enterotribe of Doyen (Fig. 3515). The musculature and mucous membrane are crushed by this instrument and a furrow of thinned-out serosa remains. This is cut between ligatures. The small remaining stump is inverted by a tobacco-pouch suture (Fig. 3514, B). In using this method on the large intestine it is advisable to put an extra suture over the tobacco-pouch stitch and even

to reenforce this by covering it by omentum. In all sutures on the colon this precaution should be taken on account of the thinness of its walls. In a lateral anastomosis one should be careful not to make the blind pouches too large, for fear of stagnation of bowel contents in them with danger of perforation. Whether one arranges the loops of the intestine in an isoperistaltic or antiperistaltic way is of no great importance as experience has proven. The intestine in lateral anastomosis has the tendency to straighten out after some time, so that the end result is practically the same as in an end-to-end anastomosis (Fig. 3516).



A B

Fig. 3514.—Closure of Divided End of Intestine; *A*, by two rows of sutures; *B*, by the tobacco-pouch suture.

Closure of Intestinal Fistulæ and Artificial Anus.—We distinguish between external intestinal fistulæ which communicate with the outer world and internal intestinal fistulæ in which the intestine communicates with another hollow viscus.

These two types may even exist in combination. In the external fecal fistula, the whole fistulous tract to the level of the skin may be covered with mucous

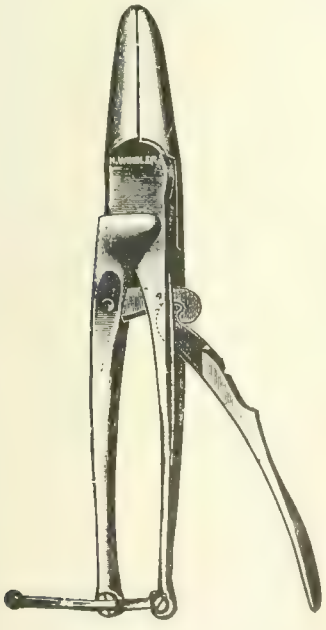


Fig. 3515.—Doyen's Enterotribe.

membrane, or there may be a direct or more or less tortuous path leading from the skin to the intestine. These latter fistulæ, which not infrequently occur after acute gangrenous appendicitis, often heal spontaneously. If the loop of intestine has been pulled up to the skin an acute angle may be formed resulting in the formation of a spur. In these cases the afferent loop is often considerably narrowed and the intestinal tube atrophied by disease, consequently all the intestinal contents will pass out through the opening; a *preternatural anus* has been formed (Fig. 3517.) This may also be complicated by a prolapse of the mucous membrane. The closure of these fistulæ may be very simple or extremely difficult, according to the anatomical conditions obtaining. It is of importance to determine the pathological cause of the fistula.

Fig. 3516.—Showing the Tendency of the Gut to Straighten out after Lateral Anastomosis.

If we have to deal with a tuberculosis or an actinomycosis of the intestine with subsequent fistula formation, the closure may be well nigh impossible. It is necessary also to find out whether all of the bowel contents pass through the fistula or whether a part of the stool passes through the rectum.

Before operation is decided upon certain measures are necessary to prepare the patient in order to insure success. If the skin is inflamed and eczematous, this condition must be treated by frequent baths, scrupulous cleaning, and application of the bismuth-oil paste, mentioned before. The bowel should be washed out through the fistula from above and through the rectum from below. Oil enemata and glycerin suppositories should be used to stimulate peristalsis in the lower part of the bowel, which has often shrunk. At the same time the skin over the fistula should be pulled together to force the stool to pass over into the efferent loop. If we have to deal with a tubular fistula, the tract may be tightly packed with gauze.

In some cases it is also advisable to stretch the sphincter in order to do away with the resistance offered by it to the fecal column. By all these means we endeavor to drive the fecal masses downward. These preliminary measures faithfully executed will, in a great measure, pave the way to success.

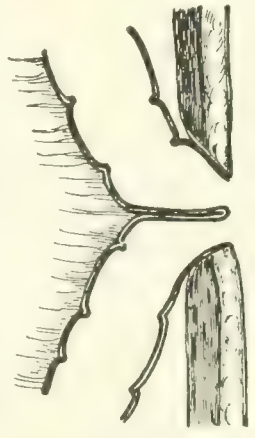


Fig. 3517.—Showing the Conversion of an Intestinal Fissure into an Artificial Anus.

The operation may be very simple or very complex and dangerous. A priori one would try to close the hole in the gut without opening the peritoneal cavity. This can often be done. The scar of the previous operation must always be excised, as the callous edges of the skin heal together poorly. The loop with the hole is carefully exposed and the defect closed by sutures. In doing this, one must be very careful to avoid tearing holes in the intestine. It is not necessary to include the mucous membrane in the suture. As the operation has to be done in infected tissues one should not suture muscles, fascia, and skin too tightly, but give the secretions a chance to escape. There must never be any tension between sutured tissues. Often these operations are not fully successful, the fistula breaking open again, although the hole may be much smaller so that finally the fistula closes on its own accord.

In very obstinate cases a skin flap plastic after Dieffenbach may be successful. In this operation, the skin is freshened around the fistula, the fascia

sewn over the intestine, and a flap, which is obtained by undermining the skin, stitched over it.

A method more certain in its results, but at the same time more complicated, is the intraperitoneal operation which leads to excision of the fistula-bearing area of the gut.

The fistula is circumcised, the loop of intestine together with the fistula is isolated and resected. An intestinal anastomosis is then made (Fig. 3518). The surgeon will always encounter more or less peritoneal adhesion. It is therefore necessary to proceed with great caution while separating them. In cases where these adhesions are very dense and extensive or in which there are other reasons to avoid doing a resection, an exclusion of the intestinal loop, bearing the fistula, can be practised.

The margins of the fistula are tightly sewn together for reasons of asepsis. The whole field of operation is carefully disinfected and the abdomen is opened some distance away from the fistula. After opening

Fig. 3518.—Resection of the Intestine with a Fistulous Tract

the peritoneal cavity, the afferent and efferent loops leading to the fistula are isolated, and a side anastomosis is made at least ten centimeters away from the fistula. The abdomen is then closed and the sutures closing the fistulæ removed.

Another method which has been described by Braun and which holds an intermediate position between resection and exclusion is the following:

After isolating the intestine the two loops are united parallel to each other by a seromuscular suture. A longitudinal incision is now made in each loop by means of a pair of scissors inserted through the fistula and the resulting wound edges of the intestine are then united by Lembert sutures.

Closure of an Artificial Anus with Spur.—For the closure of an artificial anus with spur the same methods can be used as described in the foregoing paragraphs by suture, resection, or exclusion. Suture and resection are the usual procedures, whereas exclusion is rarely performed. In closure by suture the first step of the operation is always to destroy the spur which prevents the fecal column from entering the efferent loop. This is done by a special clamp which by constant pressure crushes the spur. Such instruments are the kentrotrib of Mikulicz and Dupuytren's enterotribe. The former is an intestinal clamp the branches of which are pressed together by a screw; the latter consists of a pair of forceps with long roughly serrated blades which are held together by a piece of elastic. One blade of the forceps is inserted into the upper opening and another into the lower opening, so that when the blades are closed, the spur is grasped between them. The pressure of the blades is increased daily until the spur is destroyed.

In using these instruments one must carefully palpate the spur and apply the clamp under guidance of the fingers. The danger of perforation is present when the branches of the instrument are pushed in too deep and the intestine crushed at a place where no adhesions are present.

Sometimes the pain, which the instrument causes, is quite severe. While the clamp is in position opium should be given. The crushing of the spur is accomplished in three to four days. A rubber tube of large caliber with a stout silk thread tied around its middle, is then inserted into the bowel. This will straighten the intestinal tube and lead the bowel contents downward.

The artificial anus is transformed by this method into an ordinary fistula stercoralis, which later is closed by suture as described in the foregoing paragraph.

The closure of the artificial anus by resection with following suture of the gut is a quicker procedure but always carries with it the danger of peritonitis. The patient is usually cured sooner, but runs greater risks. Another advantage of the first method is that it can often be done under local anesthesia, which is of great value in this type of patients.

Closure of Internal Intestinal Fistulæ.—For obvious reasons it is not possible to go into details here and enumerate all the complicated pathological conditions that present themselves in connection with this topic. These fistulæ may occur between any of the hollow viscera. They may be direct or indirect. In the direct fistulæ the two organs are in close apposition whereas in the indirect fistulæ there may be a more or less tortuous tract leading first into an abscess cavity and then from there into the other organ. The writer recalls a case in which a colon fistula after a suppurative appendicitis first led into an abscess cavity of the right ovary and from there into the bladder.

The closure of these fistulæ is always very difficult and dangerous. The ideal method would be suture of the openings in both organs, with or without excision of the fistulous tract. This, however, cannot always be accomplished and then exclusion of the loop of intestine would be indicated.

Exclusion of Intestine.—A loop of intestine is "excluded" when the flow of feces is diverted from it and the loop is thereby deprived of its physiological function. The exclusion may be partial or complete. In a partial exclusion only a portion of the fecal stream is side-tracked, as in a lateral anastomosis between lower ileum and the sigmoid flexure. In complete exclusion both ends of the loop are cut and closed. This form is not practical, for the mucosa of the intestine continues to secrete, distending the loop, with danger of rupture. A complete exclusion is advisable only if a fistula of the loop exists giving outlet to the secretions, or if there is no previous fistula in existence one end of the loop must be sewn into the abdominal wound, in other words, an enterostomy must be performed. Indications for exclusion are all those conditions in which for certain reasons resection is contraindicated as in extensive ulcerative colitis, actinomycosis, tuberculosis, and inoperable tumors of the intestine.

Intestinal Obstruction.—In this section I shall deal only with the technique of the operation of acute *mechanical obstruction* without going into the details of diagnosis and the pathology of this condition. (See article *Intestinal Obstruction.*)

Acute intestinal obstruction is a condition in which there is an occlusion of the lumen of the intestine causing a complete stoppage of the onward flow of the fecal stream and of the escape of gas. In consequence, the abdomen becomes distended, often to an enormous degree, with subsequent fecal vomiting, general peritonitis and death following in a few days, if not promptly relieved. The causes of an acute obstruction are many: Incarcerated and strangulated internal and external hernia, volvulus, Meckel's diverticula, old peritoneal bands, tumors, gallstones, etc.

The surgeon is usually confronted with a patient who is desperately ill. Often there is no history of

any premonitory symptoms. The disease has developed suddenly, out of a clear sky, the patient enjoying excellent health up to a few days before. Now he is lying there with a pinched, anxious face, his eyes lying deep in their sockets, cold perspiration covering his brow, his pulse rapid and weak, his body convulsed by constant vomiting, his abdomen distended and tense as a drum. There is no possibility of diagnosing the location or the nature of the obstruction. What is to be done?

There is usually no time for a lengthy preparation, but two procedures are necessary: emptying of the bladder and washing out of the stomach. Especially the latter is of the utmost importance, for the patients aspirate easily when narcotized. Sometimes the stomach contents overflow to such an extent that the patient actually drowns in his vomitus. The danger of regurgitation from the intestines into the stomach, while handling the gut, is also constantly present. In order to avoid this, we can use the stomach tube devised by Kauch. This tube has a rubber bulb near its stomach end. This is distended when introduced and pulled up against the cardia, thus closing the esophagus and preventing the stomach contents from escaping. If this instrument is not at hand, it is advisable after having opened the abdomen to put an intestinal clamp on the jejunum near the duodenojejunal angle before proceeding with the other necessary steps of the operation.

On general principles, the incision should be made in the median line, between umbilicus and symphysis pubis, to be extended upward if necessary. We have three means at our disposal to find the cause of the obstruction. (1) Intraabdominal palpation. (2) Systematic examination of each loop of intestine. (3) Eventration. It is impossible to give any definite rules which of these three measures should be adopted, but it is safe to advise a resort to eventration only after the first two methods have proved ineffective, for patients with obstruction are usually in a state of collapse and do not bear eventration.

When the abdomen is opened the operator introduces his hand and first of all examines the cecum; if this is found collapsed, the cause of the obstruction must be in the small intestine. In order to find the obstruction under such conditions, it is best to hunt for a collapsed coil of small intestine, these are usually found crowded down into the pelvis by the distended loops. I am in the habit of marking this loop by either placing an intestinal clamp on it or by pulling a strip of gauze through a hole in the mesentery. From this fixed point on I search upward until the obstruction is found. In handling the distended gut, attention must be paid to the fact that the intestine is very easily torn, especially when ulcerations have formed in consequence of overdistention. When we approach the seat of the obstruction the same care is imperative, because if we have to deal with an internal hernia or a strangulation by a Meckel's diverticulum or by a peritoneal band, the gut may be gangrenous and easily injured.

During this search for the obstruction one assistant is entrusted with the care of the intestinal loops which may protrude from the wound. The same must be covered with towels, which are kept hot by constantly wringing them out of physiological saline solution.

The procedure to follow, after the obstruction in the small intestine has been found, is dependent upon the lesion producing the obstruction and the pathological condition of the intestine and the resisting power of the patient. In some cases the cutting of a thin band of peritoneal adhesions will suffice to relieve the condition immediately. If the loop of intestine shows signs of gangrene, this loop must be resected, when the condition of the patient allows it. Otherwise the loop should be brought out of the abdomen and a temporary fecal fistula established, which later has to be closed after the methods spoken of before.

Invagination must be reduced or, if reduction is not possible on account of adhesions, resection must be resorted to. Intestinal tumors must be removed by resection.

In cases of volvulus it is almost always necessary to resort to eventration in order to relieve the condition. If on opening the abdomen, the ascending colon is distended we have to look for an obstruction in the large intestine. The main points to be looked for are in the region of the hepatic, splenic, and sigmoid flexures. These portions of the large intestine are carefully palpated. If the obstruction is found, it is better to proceed first with the emptying of the distended loops. This can be done by enterotomy alone, or by enterotomy and introduction of a large glass tube after Moynihan upon which the intestinal loops are "telescoped." This procedure can be repeated in several places. Sometimes the introduction of a trocar and cannula will be sufficient. Moynihan describes the use of his tube as follows: "This tube has an oblique opening at one end, and a double-ringed flange at the other. The smaller flange holds tight a rubber tube which is threaded over it. The larger marks the limit to which the bowel is ondrawn. To the outer end of this tube a long, thick rubber tube is attached, and this leads into a receptacle beneath the table. The tube is pushed gently upward in the distended gut until its outer end reaches the margins of the wound in the bowel. The tube and gut are then seized in a wrap of sterile gauze and held firmly by an assistant so that no leakage occurs by the side of the tube. The surgeon then, with the greatest gentleness, pulls the intestine on to the tube and thereby empties the bowel a little higher up. Gradually more and more of the bowel is pulled onward until as much of it as the tube will take has been emptied. It will be found that upon a tube of six inches in length a portion of the bowel six feet in length can easily be held. In pulling the gut gently on to the tube it will be found to make matters easier if a piece of gauze be used to hold it. If the whole of the distended gut cannot be pulled upon the tube a piece of the bowel, at the highest point which can be reached is seized, secured by assistant and "milked" steadily downward by the surgeon. All this can, and must be done very rapidly. The tube is then gradually withdrawn, and the opening of the bowel covered by a gauze swab until all the rest of the intestine has been returned within the abdomen, where it is covered with a hot gauze swab. The bowel opening is now closed by a double layer of stitches the wound being stitched transversely, the whole loop carefully washed and cleansed, and returned gently within the abdomen." After the intestines are emptied as much as possible the next step of the operation would be to attack the cause of the obstruction. In the largest percentage of cases in the large bowel this cause will be found in a new growth, but occasionally an intussusception is found which has to be dealt with according to methods described elsewhere in this work.

In general it can be said that in all cases of acute or subacute obstruction the first aim of the surgeon must be to empty the intestine of its poisonous contents and to relieve the obstruction. Removal of the cause must often be left to a subsequent operation.

Injuries of Small and Large Intestine.—Injuries of the intestine can be caused by blunt force and by sharp weapons or bullets.

Blunt forces causing intestinal injury are manifold. A kick by a horse, a blow with the fist, a fall upon the abdomen, a wagon pole striking the patient, etc., are the most frequent causes. In all these injuries the abdominal wall itself may escape visible wounds, and still the injury to the intestine may be severe

and fatal (subcutaneous injuries). A good deal depends upon the amount of force and the direction of the blow.

According to Moty the result of the injury may be (1) a contusion, (2) a tearing of the intestine, (3) a rupture.

A contusion is brought about, if the intestine is caught between the striking object and the spinal column or the pelvic bones. Tearing of the intestine is usually caused by an indirect injury, the intestine being torn, not at the point of impact, but farther away at its point of fixation, notably in the duodenojejunal region, at the ileocolic, hepatic, or splenic flexures.

A bursting or a rupture of the intestines can happen only if the intestines are filled with gas and fluids and the loop is fixed so that the contents cannot escape quickly enough in one or the other direction (a loop of intestine caught in Douglas' pouch or in a hernial sac). Petry found among 219 subcutaneous injuries of the intestinal tract 21 cases in which the stomach was injured, 172 cases of injury to the large and small intestines (duodenum 9, jejunum 46, ileum 85, cecum 7, ascending colon 8, transverse colon 4, descending colon 5, sigmoid 5).

Contusions of the intestine may be of varying degree. If the contusion is slight, an extravasation of blood may be the only consequence. These extravasations of blood usually take place in the submucosa. They may lift up the mucosa for some distance (decollement) causing a necrosis of the same with subsequent formation of a "traumatic ulcer."

If the force of the contusion is more violent, the coats of the intestine may tear to a greater or lesser extent, thereby opening the lumen of the intestine. If the opening is small the redundant mucous membrane may prolapse, plugging the wound and, if the intestinal canal is empty, this plugging can prevent leakage and lead to healing without the development of a peritonitis. A large tear, however, will always produce a local or general peritonitis. Very serious, of course, are those cases in which the intestine is completely torn across. Here only speedy laparotomy can save the life of the patient. The seat of predilection of this injury is the duodenojejunal junction. Here the intestine is not only fixed but lies also in close contact with the vertebral column and it is easily conceivable how a force, directed against this spot, may sever the intestine completely.

Intestinal injuries by sharp instruments such as knives, swords, lances, and bullets, are usually always penetrating. In injuries by "cold steel" the size of the wound corresponds to the width of the blade, the wound margins being sharp and even. The bullet wounds vary much according to caliber and form of bullet, and whether caused by steel jacket or lead bullet. The direction of the bullet is also of importance. A bullet striking the intestine at right angles to its longitudinal axis usually produces a smaller wound, than a bullet hitting the intestine obliquely. Usually a number of coils are traversed, four to six or more perforations may be found. The wound of entrance is also smaller than the wound of exit. The destruction is greater when the shot is fired at close range than at long range. If the penetrating wound of the abdomen is large, prolapse of the intestine or of the omentum may occur. The latter organ can prolapse even through a small wound of the abdominal wall. This is a frequent complication.

Special attention has to be paid to concomitant injuries of the mesentery which may complicate the picture. Contusion, ecchymosis, hematomata may be present. Injuries of the intestines by blunt force may be complicated by injuries to the mesenteric vessels with threatening gangrene of the loops of intestine which are supplied by them. The mesentery can also be found completely torn off from the loop. The main danger to the patient in such cases is hemorrhage and intestinal gangrene with peritonitis.

The symptomatology of intestinal injuries by blunt force is very often obscure. The difficulty here lies especially in making an early diagnosis, because only speedy operation can save the patient's life. The initial symptoms of an abdominal contusion without injury to its contents may be exactly the same as the above, except that the subsequent development of the case gives a clue to the seriousness of the condition. Immediately after the injury, the patient complains of severe pain, there is always more or less shock. However, there are cases on record, where the patient, even with a ruptured intestine, has continued with his work, until he suddenly collapsed. The face of the patient has a pinched look, he is restless, respiration is increased and of the costal type. The pulse is increased in frequency and there are nausea, eructations, vomiting, and singultus.

The pain over the abdomen is mostly diffuse and the abdominal muscles are tightly contracted, giving a board-like impression to the palpating fingers (défence musculaire). De Quervain drew attention to the presence of free gas in the abdominal cavity in cases of rupture of the intestine. The collection of gas can be detected by percussing and, with a change in the patient's position, the tympany will always move to the higher parts of the abdomen. Loss of the liver dulness and its substitution by a tympanitic zone with the history of an abdominal trauma are very suggestive of a ruptured intestine.

Muscular rigidity is not pathognomonic for intestinal injuries, it is also found in inflammatory conditions and in intraabdominal bleeding.

A differential diagnosis between a contusion, a hemorrhage, tearing off of the mesentery, and rupture of the intestine is, in the beginning, always difficult and in many cases absolutely impossible. Gunshot wounds of the abdomen are almost always complicated by wounds of the intestine. This, however, is not the case in wounds of the abdomen inflicted by cutting instruments and weapons. Here the point must be decided whether the intestines are injured or not. The surgeon is, in these cases, again confronted with great difficulty. Even with an injury to the bowel, the initial symptoms may be slight or altogether missing, but procrastination in operating here spells also disaster only too often.

Treatment.—In injuries of the abdomen, whether by blunt force or by cutting instruments where there is the slightest doubt as to the integrity of the bowel, exploratory operation must be urgently advised. Should an injury of the intestines be found it must be repaired.

Slight contusions with small subserous hematomata can be left alone. If the hemorrhage, however, is extensive and the bowel wall perforated, the best procedure, and the safest, is resection of the part. Wounds made by sharp weapons must be sutured after the approved methods, described above.

Bullet wounds should also be sutured. If multiple wounds are found close together in a loop, it is better to resort to resection.

Wounds of the mesentery must be sutured and bleeding vessels must be tied. There is always a smaller or larger hematoma between the layers of the mesentery, and in addition to the ligature of the bleeding vessel, the loop of intestine supplied by this vessel must be resected, on account of subsequent gangrene of the loop. In cases in which the mesentery is torn off from the bowel, this part of the intestine should also be removed. In complete tearing apart of the intestine, the torn ends must be reunited, after freshening the ends. Before closing the abdomen, it should be carefully cleaned by flushing with physiological saline. A drain should be put into the pelvis

and lead out through the lower part of the wound or through a special stab wound, and the patient put in a high Fowler's position. Analeptics should be given and, with an uninjured colon, Murphy salines.

The *prognosis* in these cases depends entirely upon early operation; according to statistics collected by Petry, the following results were obtained: Operation in 1 to 5 hours, 100 per cent. cure; in 6 to 10 hours, 61 per cent. cure; in 11 to 15 hours, 100 per cent. cure; in 16 to 22 hours, 33.5 per cent. cure; in 21 to 60 hours, no cure.

Neoplasms of the Intestine.—Benign tumors of the small and large intestine are comparatively rare. The following types occur: Adenoma, lipoma fibroma, myoma, myxoma, teratoma. Also mixed tumors, as myo-, fibro-, and myxosarcomata have been found occasionally.

The adenomata occur in the small and large intestine especially in the young. They develop from the cells of Lieberkuehn and may be sessile or pedunculated. Their size varies from very small nodules to tumors the size of a fist. Their most frequent seat is the rectum.

A very important form is the multiple adenoma or multiple polyposis. This form is not infrequently found in the rectum, but it may also involve the whole colon. The adenomatous tumors have a tendency to degenerate into malignant tumors.

Lipomata of the intestine are rare. They occur as submucous or as subserous tumors.

Some are as small as a bean or a pea, others may be as large as a fist or a child's head. The largest that was found weighed six and one-half kilograms (Hellstroem).

The subserous variety is very rare and may occur as multiple tumors, originating from the appendices epiploicæ. They have a larger or smaller pedicle from which they may become detached, thus forming loose bodies in the abdominal cavity.

The submucous variety originate in the submucosa and are usually single. They have either a broad base or are pedunculated and are not infrequently expelled per rectum. (Ward 10 cases.) DeWitt Stetten has collected 77 cases including 2 cases of his own. They are rare in patients under 40 years. Between the ages of 40 and 60 he found 19 cases. In 31 cases they were situated in the small intestine and in 41 cases in the large intestine.

Myomata of the intestine are leiomyomata, their origin is naturally the muscular layer of the gut. They originate as intramural tumors and grow either into the lumen of the gut (submucous) or develop toward the abdominal cavity, compressing the lumen from the outside (subserous). They grow both from the longitudinal musculature and the ring musculature of the intestine. Steiner collected 51 cases, among them 21 occurred in the stomach, 14 in the small intestine, 10 in the large intestine, including the rectum.

Submucous myomata which develop into the lumen of the intestine usually remain smaller than the subserous or external tumors which have been found weighing up to fourteen pounds. They grow very slowly, have a smooth surface, the larger tumors often showing a nodular appearance. The subserous myoma develops in any part of the bowel circumference. If it grows from the side of the mesenteric attachment, it develops between the two layers of the mesentery and may simulate a mesenteric tumor. Such tumors sometimes are multiple, in one case there were found fifty small nodules. Pure fibromata are very rare, so are the mixed forms. The clinical symptoms of these tumors are very varied. Small tumors show no symptoms at all. After they have attained a certain size, they produce symptoms of chronic obstruction which may suddenly develop into a complete and acute ileus. Frequently at operations these tumors are found to be the cause of an invagination, the tumor being situated at the apex of the intussusceptum.

The treatment of these tumors depends upon the symptoms. Small adenomata in the rectum may produce slight hemorrhages, pain, and tenesmus only when they become inflamed or gangrenous. These new growths can be removed per anum by either ligating the base of the pedicle or better by completely excising them. If they are found in elderly people it is well to bear in mind their possible degeneration into carcinoma.

In cases of diffuse and multiple adenomatous polyps (diffuse polyposis) of the colon one has to consider the establishment of a preternatural anus, an exclusion or a complete resection of the affected area.

Lipomata, fibromata, myomata have to be treated according to the symptoms which they produce in the cases in question. If they are single and are situated in the submucosa projecting into the lumen of the gut, they can be removed by opening the intestine. Subserous tumors must usually be removed by resecting a portion of the intestine. Resection must also be resorted to in cases of multiple development. A case in which the tumor has been the cause of an invagination must be treated after the rules laid down elsewhere in this work.

Malignant Tumors of the Intestine.—Sarcoma of the intestinal tract is rare compared with the occurrence of carcinoma. According to v. Mikulicz, among 100 cases of intestinal neoplasm, excluding those of the rectum, there were only 5 cases of sarcoma and 1 case of endothelioma. According to Baltzer and Rheinwald, males are oftener affected than females. Baltzer reports that among 14 cases only 1 case occurred in a woman. Among 40 cases collected by Rheinwald 31 (75.5 per cent.) were found in men and only 9 in women. The sarcomata occur most frequently in the third and fourth decennium according to M. Corner and H. Fairbanks.

All varieties of sarcoma have been found. The most frequent are the small round-celled sarcomata and the lymphosarcomata. The latter often occur as multiple, scattered over large areas of the intestine. More infrequent are the spindle-celled sarcoma and the myo-, cysto-, and melanosarcomata. F. Munk observed a colloid sarcoma. The sarcomatous tumors originate, according to P. Lecène, in the intraparietal connective tissue of the intestinal wall, either from the submucosa or muscularis or from the perivascular connective tissue. Muscularis and mucosa are early involved by the growth, whereas the serosa remains free for a long time, to be affected in the latter stages of the disease. Sarcoma usually attacks the whole circumference of the intestine, rarely it stays confined to a certain portion of the gut. The lymphosarcomata are often found multiple. The size of the tumors differs greatly, some being so small that they cannot be palpated; others attaining the size of a man's head. The surface is usually smooth and nodulated. Some are hard (spindle-cell sarcoma), others show softened portions, some break down in the center forming cysts. von Mikulicz operated upon a cyst containing six liters of hemorrhagic fluid. Munk draws attention to the fact that the intestine at the site of a sarcomatous tumor is rarely stenosed, but often widened out showing a sac-like dilatation.

By this sac-like dilatation the intestinal sarcomata can be distinguished macroscopically from carcinoma. In this latter condition the lumen of the gut is almost always stenosed (Madelung, Baltzer).

Sarcoma of the intestine has the tendency to early necrotic changes, the mucous membrane is usually totally destroyed and the necrotic cavities are filled with ill-smelling masses of feces and pus. The neighboring coils of intestine are often adherent to the tumor and early metastases in mesentery, retroperitoneal glands, and other organs (peritoneum, omen-

tum, liver, spleen, bronchial and inguinal glands) are frequent.

The symptoms of the disease are very vague in the beginning. Loss of weight and appetite, slight pain in the abdomen and some irregularity in the bowel movements may be all. If a tumor is felt, it usually shows a nodular and soft surface; it may be hard or almost fluctuating in some places. Sometimes a second tumor may be felt. They are often movable for a long time. Some patients have no irregularities of bowel movements, while in others blood, mucus, and pus can be found in the stool. Symptoms of stenosis are comparatively rare, they may, however, occur if a volvulus or an invagination complicates the condition. At the same time cases have been reported lately where considerable stenosis developed without the afore-mentioned complications (Siegel, Rheinwald).

The examination of the blood shows only a secondary anemia; in two cases of lymphosarcoma a large number of hematoblasts were found (R. Schmidt).

The duration of the disease is very short. Patients die within one-half year after the onset of the disease. Sometimes they succumb to one or the other of the complications such as acute intestinal obstruction or peritonitis after perforation.

The sarcomata of the large intestine behave much as those of the small intestine. The conditions which may be confounded with sarcoma are tuberculosis and carcinoma.

The treatment of these tumors is removal by resection, or if this procedure is impossible an exclusion by enteroenterostomy is advisable as a palliative measure.

Lymphosarcomata are often not amenable to surgical treatment as they are disseminated over various areas of the intestine.

Carcinomata of the small intestine are much less frequent than those of the colon and rectum. In these two latter regions carcinoma is a frequently observed malady and furnishes the bulk of all tumors of the intestine.

Among 5,621 autopsies of the Pathological Institute in Bern, 1866–1891, 521 cases of carcinoma of all organs were recorded (Max Müller). Among these were found: in the jejunum and ileum, 3; in the duodenum, 6; in the colon, 13; in the rectum, 19. Carcinoma occurs just as frequently in females as in males. The average age is forty-two. One case is reported in a child three and one-half years old.

They originate from the cylindrical epithelium of the gut and are therefore either cylindrical adenocarcinoma, scirrhous carcinoma, or gelatinous adenocarcinoma.

The ileum is more frequently attacked than the jejunum. The lumen of the intestine is always stenosed by the growth of the tumor so that the patient gets up an acute ileus before the tumor is palpable. Adhesions and secondary inflammation are frequent and may constitute insurmountable difficulties for radical operation. Metastases occur comparatively late (Haussmann, Maydl) and they are therefore relatively benign and if diagnosed early enough, give some prospect of a cure. Metastases are most frequently found in the mesenteric glands and in quite a few cases a dissemination of miliary carcinoma—nodules are found on the serosa of the intestine and on the parietal peritoneum. Other organs in which matastases occur are the liver and kidneys, more rarely the lung.

The *symptoms* are those of stenosis (acute or chronic) of the intestine with cachexia and vague or localized abdominal pain with or without a palpable tumor.

The *treatment* of these tumors is resection when possible.

Carcinoma of the Colon.—This form of malignant intestinal growth is the most frequent one with which the surgeon has to deal. It usually occurs in the form of the cylindroepithelial adenocarcinoma. Rarer forms are the medullary, the colloid, and scirrhous carcinoma.

The tumor starts, as its name implies, from the cylindrical epithelium of the mucous membrane of the colon. The wall of the gut is early infiltrated by the growth, causing thickening of its walls with inflammatory reaction of the serous coat over the tumor, thus leading to widespread and dense adhesions with neighboring organs (stomach, bladder). Carcinoma of the colon has a tendency to early ulceration with subsequent bleeding and a discharge of necrotic substances and pus.

Perforation into the stomach, when the transverse colon is the seat of the tumor, or into the bladder in sigmoid flexure carcinoma, has been observed not infrequently. The tumor may occur as a solitary, well-circumscribed, soft, fungous mass, or may infiltrate a considerable portion of the gut transforming it into a rigid tube. Their circular growth produces sooner or later a stenosis with its consequences of hypertrophy and dilatation of the gut above the stricture.

Carcinoma of the colon shows a predilection for certain regions. It is found in the cecum near the ileocolic junction, sometimes originating from the lips of the ileocolic valve, at the hepatic, at the splenic, and at the sigmoid flexures.

The cecum and the sigmoid flexure are the most common locations. They have the tendency to develop insidiously and to grow slowly with late metastasis in other organs (mesocolic and retroperitoneal glands, liver.) For these reasons they give a fairly good prognosis if early attacked surgically. Here again the difficulty of an early diagnosis is great, and patients are hard to persuade to submit to an exploratory operation, when the suspicion of a colon carcinoma is raised, on account of the slight discomfort they experience.

As pointed out before, metastases are late in developing. We find them most commonly located in the liver, lymph glands, and the peritoneum. In cases of colloid carcinoma metastases usually occur earlier and are widely spread, especially in the peritoneum, lymph glands, and bones, not so much in the liver. Scirrhous carcinoma tends especially to liver metastasis.

Symptoms—The clinical picture of this disease is very manifold. We see cases in which there are indistinct symptoms of discomfort and pain, mostly of a more or less severe colicky character, with signs of chronic obstruction. In other cases again there are no symptoms of an abdominal condition at all until suddenly an acute ileus develops. If the abdomen is opened, one is often surprised at the tight stricture of the gut not having produced an absolute obstruction sooner. As a direct cause of the ileus, one not infrequently finds a foreign body, a small piece of bone, a cherry pit, or the like. In one of the author's cases the acute obstruction was caused by an undigested grape. An invagination or a volvulus may also be responsible for the acute symptoms.

In the majority of the cases the course and development are slow and latent. The patients complain of being generally out of sorts. They have indefinite dyspeptic symptoms, with more or less constipation, sometimes alternating with attacks of diarrhea. There is a vague or definite colic-like pain in the abdomen accompanied by rumbling noises of gas and local tympanites. When the tumor is located in the colon ascendens, a very much distended caput coli can often be seen and is sometimes noticed by the patient himself. After some time, a tumor may be palpable along the course of the colon. At the hepatic and splenic flexures the tumor may attain considerable

size before it can be felt. It is usually irregular in shape, nodular, hard, and more or less immovable on account of its being adherent to neighboring organs.

When ulceration of the tumor has occurred blood will appear in the stool. The quantity of blood may be very small, it being therefore necessary to examine for "occult blood" by the different chemical methods. This examination should never be neglected in cases of a suspicion of a carcinoma of the

Fig. 3519.—Showing the Successive Steps of Resection of the Cecum and Ascending Colon for Carcinoma. First step, division of the ileum and mesentery.

colon. If a tumor of the sigmoid flexure is suspected, it can sometimes be seen by sigmoidoscopy. Differential diagnosis of tuberculosis, actinomycosis, chronic diverticulitis, and syphilis has to be considered. This, however, is in most of the cases, very

Fig. 3520.—Same as Fig. 3519. Second step, ileocolonic anastomosis.

difficult and the condition can be recognized only after laparotomy and microscopical diagnosis.

Treatment is entirely surgical. The mode of procedure differs with the condition of the patient. Where a tumor can be palpated and the condition of the patient is fair, primary resection is always to be preferred. If the tumor is located in the cecum, colon ascendens or hepatic flexure, it is well to remove this part of the intestine and to do side-to-side implantation of the ileum into the transverse colon with closure of both ends. (Figs. 3519–3522.) If the trans-

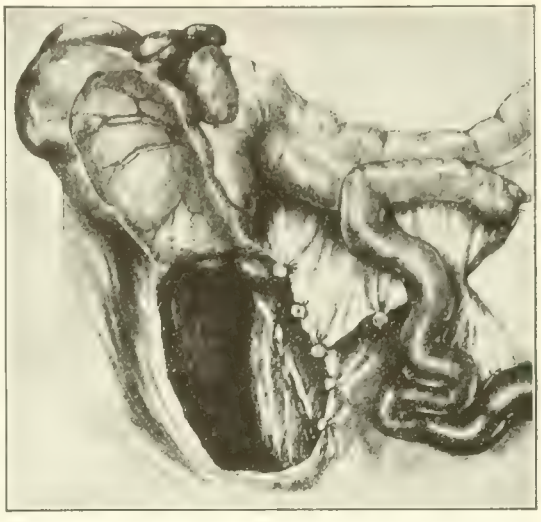


Fig. 3521.—Same as Fig. 3519. Third step, resection of the cecum.

verse colon and the other parts of the colon are affected, resection and lateral anastomosis should be done. In cases where there is an acute obstruction or a chronic obstruction with much distention, it is preferable simply to establish a preternatural anus and

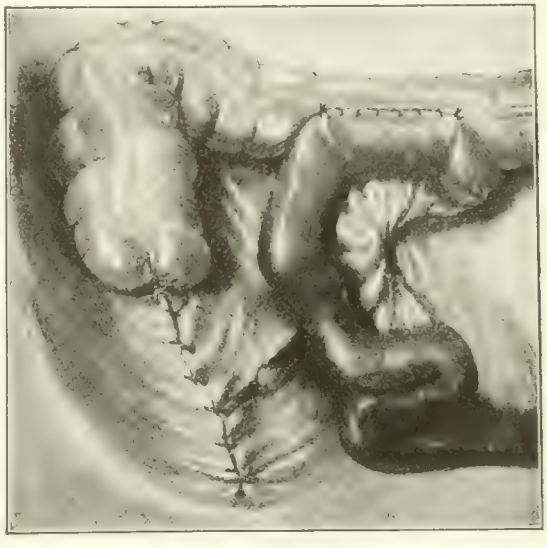


Fig. 3522.—Same as Fig. 3519. Completed operation.

to remove the tumor at a later operation. If the tumor cannot be removed, enteroanastomosis ought to be done if no obstruction exists.

The duration of the disease is from two to four years, two years being about the average.

Hermann Fischer.

Intestines, Anatomy of.—See *Digestive Tract.*

Intestines, New Growths of.—See *Intestinal Surgery.*

Intestines, Physiology of.—See *Absorption, Digestion, and Intestinal Movements.*

Intestines, Tuberculosis of.—This is the most common specific infection of the intestinal tract. It occurs both as a *primary* and a *secondary* process, the lesions being rarest in the duodenum and increasing in frequency toward the ileocecal valve to become more rare in the large intestine. In the lower part of the ileum, particularly on the upper surface of the ileocecal valve, tuberculous lesions are found in nearly all cases (about ninety per cent.) of advanced pulmonary tuberculosis. In rare cases the small intestine may be entirely free from the disease, while the colon and rectum are extensively involved. Still more rarely isolated tuberculous ulcers are found in the duodenum without the occurrence of other intestinal lesions.

In the *primary* form the infection occurs through the ingestion of tubercle bacilli in the food or through the swallowing of saliva containing bacilli that have entered the upper respiratory tract with the dust of the air. *Secondary* intestinal tuberculosis is nearly always due to the swallowing of sputum containing tubercle bacilli derived from pulmonary lesions. In a small number of cases the intestinal lesions are secondary to tuberculosis of the upper respiratory tract or upper portion of the alimentary tract, or they may be metastatic in origin from primary foci situated in any part of the body. Hematogenous (miliary) tuberculosis of the intestines is very much more rare than the enterogenous infections. Still more rarely the intestine is involved secondarily by extension of tuberculous processes from other organs (kidney, ovaries, mesenteric glands, etc.).

Primary Tuberculosis of the Intestines.—A very great difference of opinion exists as to the frequency of primary intestinal tuberculosis. The experience of different pathologists varies so greatly, even when in the same city and under apparently similar conditions, that no certain conclusion can be drawn from the statistics as they stand at present. The majority of German pathologists regard primary intestinal tuberculosis as rare, although several competent observers rate its occurrence as from five to twenty-five per cent. of all cases of tuberculosis in young children. English writers believe that primary tuberculosis of the intestines is not infrequent in children, while in America individual experience and the resulting opinions vary greatly. The total number of reported cases of undoubted primary intestinal lesions is very small, however, in proportion to the great frequency of deaths from tuberculosis. The question of the infrequency of primary intestinal lesions does not, moreover, affect that concerning the intestines as a frequent avenue of entrance of tubercle bacilli, since it has been shown that tubercle bacilli may pass through the intestinal wall without exciting there any lesion. Further, in many cases the seat of the primary infection may be wholly overshadowed by the more rapidly developing secondary or general conditions.

Either the bovine or the human strain of tubercle bacillus may cause primary lesions in the intestine, the former entering the body in milk or its products, while the latter enters with the dust of the air and is swallowed in the saliva. The bovine form is more likely to occur in children, and a number of undoubted cases of primary intestinal lesions due to bovine bacilli have been reported. It is possible that the bovine form is more common than is generally believed. The relative freedom of the intestine from tuberculous lesions as compared to the greater frequency with which the mesenteric glands are involved may also be due to the fact that a slight tuberculous lesion of the intestine may disappear leaving no trace, while the secondary process in the lymph nodes increases in severity and appears as the primary localization of the disease. The greater permeability of the mucosa of the intestine in children is also a factor to be considered.

Secondary Form of Intestinal Tuberculosis. In the later stages of pulmonary tuberculosis, or less frequently at an early period of development of the disease, involvement of the intestine results from the bacilli swallowed in the sputum or saliva. The lesions usually occur in the lower part of the ileum and involve particularly the lymphoid structures. The bacilli in the intestinal contents adhere to the surface of the mucosa and pass through it, being carried most probably for the greater part by leucocytes to the lymph follicles. Various authorities assert that the intestinal lesions always begin in the lymphoid tissue, but very minute microscopical tubercles may be found in the stroma of the mucosa or submucosa entirely independent of the lymphoid structures.

General Pathology of Intestinal Tuberculosis. Tuberculosis of the intestine occurs in two forms, the *ulcerative* and the *hyperplastic*. The *ulcerative* form is by far the more common. The bacilli gaining entrance into the stroma of the mucosa or into the lymphoid tissue of the solitary follicles or Peyer's patches, cause first a local degeneration or necrosis which is followed by the formation of a characteristic subepithelial miliary tubercle. These may be isolated or multiple, and in the latter case may become confluent. As they increase in size they undergo central caseation and softening, and appear as opaque yellowish nodules elevated above the surface of the mucosa. As the caseation increases, the overlying mucosa becomes involved and the caseous material is liberated into the intestinal lumen, leaving a small round, punched-out cavity in the center of the miliary nodules (lenticular ulcer). With the extension of the process these caseous cavities become larger and take on the character of ulcers having more or less ragged, often undermined edges surrounded by an elevated border in which grayish translucent or yellowish opaque miliary nodules are usually present. The floor of the ulcer is covered with caseous material and may also be set with miliary tubercles. The process is usually shallow in the majority of cases, but the caseation and subsequent erosion may extend to any depth in the intestinal wall, not infrequently into the muscle coats. Rapidly developing tuberculous ulcers may lead to perforation, either into the peritoneal cavity or into a neighboring coil of intestine in case adhesions have formed. More often there is a local peritonitis leading to the formation of adhesions or local thickenings of the peritoneum preventing perforation into the general peritoneal cavity. Perforation into or between such adhesions may lead to the formation of fecal abscesses. Very rarely perforation into the bladder or uterus or through the abdominal wall may occur.

In the more slowly growing ulcers there is usually an abundant formation of tuberculous granulation tissue in the base of the ulcer or about its edges. This tissue may be so abundantly produced as to cause marked thickening of the wall of the intestine and a constriction of the lumen. Caseous foci are usually present throughout the granulation tissue. Although an entire Peyer's patch may become involved in the ulcer, the long axis of the latter is usually transverse so that "ring" or "girdle ulcers" encircling the intestine are produced. Tuberculous ulcers may be distinguished from typhoid ulcers by the fact that the long axis of the ulcer is usually parallel with the transverse axis of the intestine, the edges are nodular and more or less undermined and irregular, the floor is less smooth, eschars are rarely seen, and the serosa over the ulcer shows miliary nodules. The mieroscopic diagnosis is, of course, easy. Only in

rare cases may the condition be mistaken; in very acute and virulent forms of tubercle-bacillus infections there may occur a rapid caseation and ulceration of the mucosa and submucosa without tubercle formation. The caseous eschar may be mistaken for a typhoidal ulcer, if it is not stained for tubercle-bacilli. The tuberculous process extends along the lymphatics of the intestinal wall, and a tuberculous lymphangitis is practically always present in the immediate neighborhood of the ulcer. The involved lymph-vessels appear to the naked eye as tortuous whitish beaded lines or cords. Miliary tubercles may be found along the course of the affected vessels. The resulting chyle stasis leads to general or local dilatations of the lymphatics, in the latter case appearing as chyle cysts. Miliary nodules occur in the subserosa near the ulcer, and the site of the intestinal ulcer can be told by the local peritonitis and lymphangitis, and the mesenteric glands are always involved in such cases. In many cases tuberculous lesions are found also in the thoracic duct. From these the bacilli may be given off into the lymph and thence into the blood stream in such numbers that a general miliary tuberculosis is produced. Moreover, tubercle bacilli may pass into the thoracic duct from the intestinal lesion or the caseous mesenteric glands, and reach the blood-stream without exciting any lesions in the duct itself. The importance of intestinal tuberculosis in the production of reinfections and widespread metastases is very evident.

Small isolated tuberculous ulcers in a state of repair may occasionally be found in the intestinal wall, particularly in patients dying during the early stages of a pulmonary tuberculosis. Regeneration of the mucosa to a greater or lesser degree is often found about the edges of the more chronic ulcers. The new-forming epithelium pushes in from the sides and overhangs the floor of the ulcer, often forming polypoid growths. Contraction of the ulcer during the healing process may lead to a stenosis of the intestinal lumen. The mucosa of the intestine in the neighborhood of the tuberculous lesions presents the picture of a subacute or chronic catarrhal inflammation, or more rarely that of a diphtheritic enteritis or colitis. Diarrhea is usually present in the advanced cases, and this symptom is the result of the diffuse inflammatory changes in the mucosa.

In advanced progressive cases the lesions in the ileum increase in size and severity toward the ileocecal valve. Through the confluence of the ulcers a large portion of the mucosa may be destroyed. In addition to the larger ulcers hundreds of small tuberculous erosions may be found over miliary tubercles scattered throughout the mucosa or located in the solitary follicles. The small-intestine aspect of the ileocecal valve usually presents the most marked ulceration. In the *colon* the ulcers are rarely ring-shaped, but are usually round or irregular, and more shallow than those in the ileum. In many cases they are more numerous in the cecum and ascending colon, and diminish in number in the transverse and descending colon to become more numerous again in the *rectum*. The tuberculous process in the mucosa of the rectum is often associated with the formation of perirectal tubercles leading to the formation of fistulous tracts opening in or about the anus. The entire rectal mucosa may become ulcerated or greatly thickened from the formation of tuberculous granulation tissue. Numerous false passages may be formed. Polypoid growths may develop or a stricture may result.

The *appendix* may be involved in the advanced cases, the pathological picture being the same as that seen in the large intestine. Miliary tubercles may be found in the mucosa or submucosa, or the mucosa may contain tuberculous ulcers. Occasionally the entire appendix is converted into a sac filled with caseous material. The appendix may also contain secondary miliary tubercles in cases of primary tuberculosis of the Fallopian tubes, the remaining portion of the intestine showing no lesions. *Primary* appendiceal tuberculosis is relatively rare. The pathological picture may be the same as that seen in the secondary form, or tubercles may develop primarily in the serosa, subserosa, or muscle coats of the appendix. The lymph nodes in the mesoappendix may be primarily involved.

Hyperplastic Variety of Intestinal Tuberculosis.—A rare form of intestinal tuberculosis is that associated with a marked thickening of the intestinal wall due to the formation of tubercles in the submucosa and muscularis. The overlying mucosa may show no change beyond that of atrophy. Ulceration may be entirely absent. There is little or no caseation. The ileocecal region is usually affected, although the process may involve any coils that become adherent to the seat of the primary lesion. Strictures of the intestine may be produced at intervals, while the intervening portions of the intestine may be relatively normal or show a much less advanced stage of the disease. In the neighborhood of the constrictions the peritoneum is usually studded with pedunculated masses of tubercles, and the neighboring mesentery is thickened and infiltrated with tuberculous granulation tissue. The corresponding mesenteric glands are tuberculous. Polypoid masses of tubercle may also project into the lumen of the bowel. These may be covered with mucosa, either normal or atrophic, but rarely showing ulceration. In some cases typical tubercles are not formed; the tissues are found to be infiltrated with round cells without epithelioid cells or caseation, although tubercle bacilli can be demonstrated in great numbers between the cells of the infiltration. The condition of hyperplastic intestinal tuberculosis is usually primary; only rarely is it accompanied by pulmonary disease. In the later stages of the disease the infection may become generalized, and death usually results from such complications. The slow development of the disease and its peculiar pathology point to an infection with a strain of tubercle bacillus of relatively low virulence.

Symptoms.—The symptoms of intestinal tuberculosis, whether primary or secondary, are often vague. Diarrhea and constipation may alternate, or either one of these symptoms may be the predominant feature. Colicky pains may be present, occurring mostly in the lower part of the abdomen. These may be transient and of a slight degree, or severe and persistent. The pain is usually more severe after eating or preceding bowel movements. Nausea and vomiting may accompany the pain. In many cases a marked thirst is present. Blood in the stools visible to the naked eye is rare, but the occult test may reveal its presence in the ulcerative forms. Tubercle bacilli may be found in the stools, but as the presence of the bacilli in the feces may be due to the swallowing of sputum containing them their presence cannot be taken as a positive sign of intestinal involvement. In the more advanced cases a chronic diarrhea is usually present. The symptoms of secondary intestinal tuberculosis are often entirely obscured by the severity of the primary pulmonary affection. The presence of the intestinal involvement may be revealed only through the occurrence of a severe hemorrhage from the bowels, or the symptoms of a stenosis. The symptoms of a *tuberculous appendicitis* are also very vague, and the condition has usually been discovered only at autopsy. The writer has seen several cases in which the appendix removed for symptoms of appendicitis showed the presence of tubercles in the absence of symptoms of tuberculosis elsewhere in the body. In rectal tuberculosis the chief symptom is the pain which may be constant or intermittent. It is increased by defecation. Symptoms of rectal stenosis may develop in rare cases.

In the absence of symptoms of tuberculosis elsewhere in the body the clinical complex of loss of weight, fever, night-sweats, etc., in connection with alternating diarrhea and constipation, abdominal pain, etc., would indicate a primary intestinal tuberculosis.

The symptoms of the *hypertrophic form* are also vague. Loss of weight, weakness, abdominal pains with crises corresponding to temporary obstruction of the intestinal lumen at the points of stricture, alternating diarrhea and constipation, nausea and vomiting, slowly developing abdominal tumor, etc., point to the existence of a hypertrophic intestinal tuberculosis. Fever is usually absent in this form; and characteristic painful points are not present. Distention of the abdomen is rare. The tumors are usually multiple, often cylindrical in shape, and are more or less movable. They are tender on deep palpation, and show a progressive increase in size. In the cases with well-marked stenoses characteristic gurgling borborygmi may often be heard at the end of the colicky attacks as the result of the passage of gas and fluids through the stenosis. As the degree of stenosis increases, the symptoms of obstruction become more pronounced and the characteristic vomiting of this condition may then occur. In the early stages the vomiting is not suggestive of either obstruction, appendicitis, or peritonitis. The general picture may suggest the existence of malignant intestinal disease, and the condition is sometimes mistaken for the latter, even at operation. Hyperplastic tuberculosis of the intestine is, however, seen most frequently in early adult life.

Diagnosis.—The diagnosis of primary tuberculosis of the intestines of the ulcerative type rests upon the occurrence of diarrhea alternating with constipation, of a chronic diarrhea associated with abdominal pain, emaciation, night-sweats, fever, etc. The tuberculin test may be employed in doubtful cases, or the opsonic index taken on several successive days may serve as a factor in the diagnosis. The stools should be examined for tubercle bacilli according to the method of Strassburger. They are diluted and sedimented first with water and then with alcohol, thereby decreasing the specific gravity and hastening sedimentation. The final sediment thus obtained may be utilized for making smears that are to be stained in the usual way.

In the differential diagnosis of primary hypertrophic tuberculosis of the intestine the presence of a tumor or tumors showing progressive enlargement, without generalized distention, fever, or leucocytosis would serve to differentiate this condition from appendicitis. In the differentiation from malignant disease of some one of the abdominal organs the tuberculin test, Calmette's reaction, the opsonic index, etc., may be used as diagnostic acids. Exploratory operation may ultimately be indicated.

The diagnosis of secondary intestinal tuberculosis is often difficult or impossible, since the intestinal condition may be masked by the more severe general symptoms. Intestinal involvement may safely be assumed to exist in practically every case of advanced pulmonary tuberculosis. Symptoms of enteritis usually indicate its existence.

Prognosis.—Undoubtedly patients with primary tuberculosis of the intestine may recover. There is good reason to believe that small lesions at the point of entrance of the bacilli in the intestinal mucosa may entirely disappear. Secondary lesions sometimes heal, but as the majority of these occur in advanced cases of pulmonary disease the prognosis is usually hopeless. In the case of the hypertrophic form early operation may effect a cure; but at the stage in which the affection is usually recognized and operated upon generalization of the infection commonly occurs after one or more years.

Treatment.—The medical treatment of intestinal tuberculosis is almost wholly symptomatic, and usually without much effect. The regulation of the diet is the most important factor in checking the symptoms of enteritis. Fruits, vegetables, etc., are to be prohibited. In very severe cases it may be necessary to resort to the use of boiled milk or albumin water. Lime water may be used with the milk. The general treatment is that accorded late stages of pulmonary tuberculosis.

Local applications, ice or hot-water bag, turpentine stupes, abdominal bandages, etc., may serve to relieve the abdominal pain in those cases in which this is a serious symptom. Irrigation with salt solution to which a few drops of laudanum have been added is recommended. Injections of four to eight grams of bismuth subnitrate in 250 to 300 c.c. of warm water are also advocated. Enemata of starch and laudanum, or suppositories of opium or morphine, become necessary in the great majority of cases.

In the case of primary intestinal tuberculosis, particularly of the hyperplastic type, the excision of the affected portion of the bowel offers a hope of recovery in these patients in whom an early diagnosis is made. The ileocecal portion of the gut may be resected and the local lymph nodes removed. The after-treatment should be that directed against tuberculous infection in general. When excision is impossible a lateral anastomosis may effect great relief. The treatment of tuberculous appendicitis, perirectal abscess, fistula in ano, etc., becomes ultimately surgical, although the usual symptomatic medical measures may be used according to indications. Excision of the abscess or fistulous tract may result in complete healing. A similar result has also followed the injection of mercurial ointment. Aldred Scott Warthin.

Intravenous Injections.—The method of intravenous injection has grown from the simple transfusion of blood and of physiological salt solution, both of which procedures have been practised for many years, to comprehend the administration, in this manner, of a considerable number of biological products and medicinal substances.

The process is closely allied in effect to the hypodermic exhibition of remedies, but some advantages, under certain circumstances, are claimed for this method, although it is not by any means so convenient, so simple, or so easy of performance as hypodermic medication. The action of appropriate remedial agents when introduced directly into the blood is prompter than can be obtained by the subcutaneous method—it is virtually immediate—and the results are not dependent upon uncertain, tardy, or delayed absorption; local irritation of the tissues, which is caused by some solutions when injected subcutaneously may be thus avoided and bulky doses may be administered without discomfort to the patient; but the fact that strong or irritant solutions introduced directly into the veins, may injuriously affect the tissues with which they come in contact cannot be ignored, for phlebitis and endocarditis have followed the use of some injections, and secondary or remote injury may also ensue. To avoid disastrous consequences, great care and good judgment should prevail in the technique and in the selection and preparation of the solutions employed.

The operation may be performed with an ordinary small, short hypodermic needle to which is attached an irrigator or a syringe of varying size and construction to meet the exigencies of the particular case. An appropriate instrument for common use is an all-glass syringe, having a capacity of 2 to 100 c.c., Fig. 3523, with an accurately fitted glass plunger, all of which may be made thoroughly aseptic.

In pursuance of this plan of treatment, the patient, when practicable, should abstain from food for several

hours preceding the operation. The recumbent posture should invariably be assumed and it should be maintained, in some instances, for three or four hours at least after the injection has been made and until the reaction has subsided. A suitable vein must be selected and exactly defined, usually, a vein at the flexion of the elbow—either the median basilic or the median cephalic. If the median basilic—which is the larger of the two veins—should be chosen for the puncture, its relation to the brachial artery should be borne in mind. To facilitate the procedure, a firmly applied bandage may then be placed around the arm below the shoulder for the purpose of distending the vein. This compression should be removed after the puncture of the vein but always before the injection of the solution. When the needle is withdrawn, the

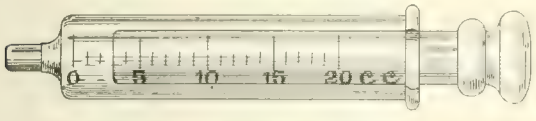


Fig. 3523.—The All-glass Syringe for Intravenous Injection

site of the puncture may be covered by a drop of flexible collodion. If a tube or cannula is used in preference to a needle, the vein, after local anesthesia, should be carefully dissected out and a longitudinal incision of sufficient size to admit the tube should be made in it. Subsequently, the opening should be closed by a suitable compress.

The surface of the body at the point selected for the injection, and the hands of the operator, as well as the instrument and the solution employed, should be aseptic. The needle, held at a very acute angle to the axis of the vein, should enter, but should not transfix or penetrate beyond the vessel. The warmed solution should be thrown very slowly in the direction of the blood current and care should be taken to prevent the entrance of air into the vein.

The systemic reaction following some injections may be very pronounced, so much, in fact, that confinement to bed for a day or two may be necessary, but this degree of disturbance is not ordinarily to be anticipated, and in some instances, of course, no reaction is appreciable. The symptoms characterizing the reaction which may be expected to occur in twenty minutes to three or four hours after the injection, are usually fever of one to five degrees, headache, occasionally rigors or a well-defined chill and sweating. Sometimes, associated with these symptoms, are abdominal pains, nausea, vomiting, faintness, diarrhea, with a general sensation of tingling or numbness. A too rapid injection may cause more or less shock.

It is maintained by many conservative practitioners that inasmuch as intramuscular injections act quicker than subcutaneous injections and nearly as quick as intravenous injections and are safer—being entirely free from all risks—they should be preferred, and should therefore supplant the intravenous method. This view is not, by any means, uniformly accepted, but, quite to the contrary, the popularity of intravenous medication appears to be decidedly on the increase, and, besides, the two methods are not in every instance interchangeable.

Salvarsan and neosalvarsan are commonly given intravenously. This is the least painful and the quickest method, and the visible lesions of syphilis soon disappear after their use. Their elimination, however, is rapid, and surely it is more prudent in the treatment of syphilitic infection to follow the initial dose, either by other injections of like kind or by subcutaneous or intramuscular injections of the drug or by the ordinary mercurial course.

Physiological salt solution may be profitably injected into the veins in cases of ptomaine poisoning with a view of promoting and hastening elimination. It is recommended also in scarlatina when the toxic influence is profound; in excessive hemorrhage and, with the addition of an alkali, in diabetic coma and in eclampsia.

For insolation and for anuria an alkaline saline intravenous injection is strongly indorsed. It will usually provoke prompt and abundant action of the kidneys. One or two liters (one or two quarts) of a warm, aseptic solution consisting of chloride of sodium, gm. 14 (ʒ iijss), and carbonate of sodium

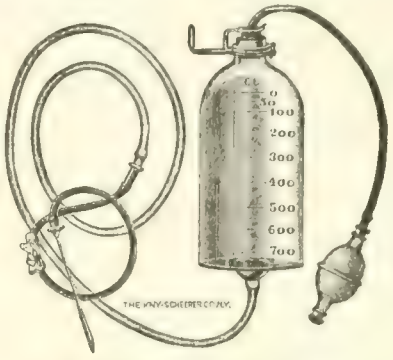


Fig. 3524.—Kelly's Infusion Apparatus.

(crystals), gm. 10 (ʒ ijss) to water, 1,000 c.c. (Oij) may be very slowly introduced and repeated after four to six hours, if required, with the confident expectation of arousing renal activity more quickly and more completely than by any other available mode of treatment.

The intravenous injection of freshly distilled water has been practised with success in severe cases of pyemia and of septicemia.

For the administration of saline solutions, the infusion apparatus of Kelly, Fig. 3524, with a capacity of 700 c.c. (ʒ xxiv) is entirely satisfactory and so is the excellent apparatus of Fowler, Fig. 3525, which is

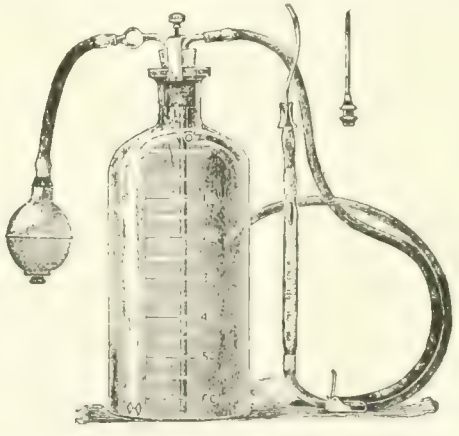


Fig. 3525.—Fowler's Infusion Apparatus.

made in two sizes—thirty and sixty ounces respectively and is fully equipped, including a thermometer so affixed to the tube as to indicate the exact temperature of the solution as it passes into the vein. These apparatuses may be fitted with needles, with or without cannulæ, or with intravenous infusion tubes, straight or curved, of glass or of metal, to suit the preference of the operator.

Among the drugs now used intravenously are bichloride of mercury, in small doses daily; cacodylate of sodium, in malarial infection, pellagra, and syphilis;

strophanthin, one milligram (gr. $\frac{1}{60}$), as a heart tonic; paraldehyde, in some cases of nervous and mental derangement; water of ammonia, as a diffusible stimulant; emetine hydrochloride, in amebic dysentery; ether, to induce general anesthesia; theobromine sodium salicylate, dose one gram (gr. xv) in a five per cent. aqueous solution, in uremic conditions; whisky and adrenalin to relieve shock and to stimulate the circulation; any of the alkaloids when extra quick action is sought, and sodium salicylate, in doses of one gram (gr. xv) two or three times daily for a week or more. The latter drug given in this way has a distinct field of usefulness in rheumatic fever, being applicable to cases in which its administration in the routine way is impracticable or unsatisfactory.

Tetanus antitoxin may be injected directly into the veins. If used for immunizing purposes, moderate doses of 1,500 to 2,000 units may be given subcutaneously, but after tetanic symptoms have become manifest and when time is an important element in the treatment, the intravenous administration, in large doses—10,000 to 20,000 units, repeated every six hours, if required—should be adopted without delay.

Calmette's antivenin should be given in this manner in doses of not less than 100 c.c. as soon as possible after the bite of a venomous reptile.

Diphtheria antitoxin and other therapeutic serums may be thus used when speedy results are desired. In laryngeal or malignant diphtheria, large doses of the antitoxin—10,000 to 20,000 units, or, in exceptional cases, even more, frequently repeated, should be given intravenously. It is probable that the serum used in this way is several times more effective than it is when given subcutaneously in corresponding doses.

Age is not a contraindication. Intravenous injections may be used at any age—at both extremes of life, but special caution should be observed in very feeble subjects, or in persons presenting serious impairment, from any cause, of the circulatory function or of any vital organ. JAMES B. BAIRD.

Intubation.—In 1856 Bouchut suggested and actually practised a crude method of intubation, which, however, the ridicule of his confrères soon forced him to abandon. Before this time, catheterization of the larynx had been practised to a certain extent for the temporary relief of urgent symptoms of stenosis, but with little success. In 1880 Dr. Joseph O'Dwyer, of New York, with no previous knowledge of the experiments of Bouchut, began to study the subject of intubation. This work extended over a period of three years and was performed at the New York Foundling Hospital, where the operation of tracheotomy had given such fatal results that it had long since been abandoned. After many failures and a few partial successes, Dr. O'Dwyer gave to the world the perfected instruments as they are made to-day.

Intubation is now the operation of election in America as well as on the Continent of Europe. In England tracheotomy is still largely practised—notwithstanding the obvious advantages of intubation, viz., it is bloodless, the inspired air reaches the lungs at the proper temperature, the after-care of the patient is much less exacting, and usually of shorter duration, and in practised hands the results are much more favorable to life. The sole advantage possessed by tracheotomy is that it can be performed in a fairly satisfactory manner without much or any previous experience and is therefore more generally available in an emergency, whereas intubationists of experience (and no other should attempt the operation) are not always to be obtained. Secondary tracheotomy is occasionally necessary when intubation has failed to give relief, as when the membrane or other obstruction reaches below the bifurcation of the trachea, or when, for various reasons, there is constant autoextubation.

Intubation Instruments.—The tubes are made of hard rubber, vulcanized rubber, and metal lined, the all-metal tubes being now seldom used. An ordinary intubation set contains six or seven tubes for the various ages from a year to twelve years. They are very closely adapted to the anatomy of the larynx and trachea thus minimizing the tendency to ulceration of the mucous membrane by pressure. A metal scale for determining the proper tube for a given age accompanies each set of instruments. The tubes (Fig. 3526, Nos. II. and III.) are long enough to reach nearly to the bifurcation of the trachea, thus lessening the chance of obstruction by loose membrane. The retaining swell is sufficiently full to keep the tube in place and yet small enough to allow of ready expulsion by coughing when the lumen is blocked. The neck is narrow and adapted to the grip of the vocal cords. When the tube is *in situ* the flattened head and upper opening are perfectly covered by the epiglottis.

FIG. 3526.—Intubation Tubes. No. I., Granulation tube; No. II., lateral view of ordinary tube; No. III., anterior view of the same.

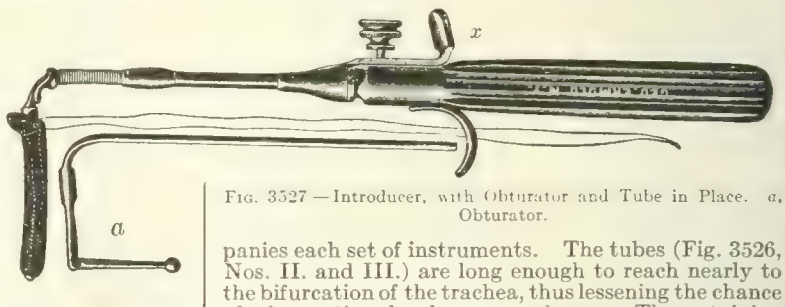


FIG. 3527.—Introducer, with Obturator and Tube in Place. *a*, Obturator.

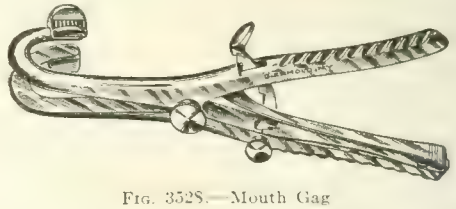


FIG. 3528.—Mouth Gag

A general idea of the tubes, introducer, gag, and extractor may be obtained from the accompanying illustrations. The obturator (Fig. 3527, *a*), one for

each tube, fits into the introducer and is released from the tube by the thumb of the operator pushing forward the button at *x*, or by the forefinger with the introducers now used at Willard Parker Hospital, *x* being on the side of the instrument instead of on top. The mouth gag (Fig. 3528) is a powerful instrument and need not be used in young infants as it has the undesirable property of lacerating toothless gums. If it is used on the latter it should be padded with cotton wound about the ends.

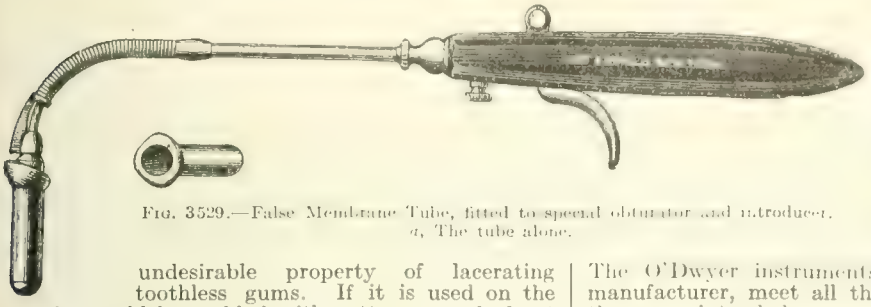


Fig. 3529.—False Membrane Tube, fitted to special obturator and introducer. *a*, The tube alone.

In addition to the regular tubes there are tubes especially adapted to getting rid of loose pseudomembrane. These are hollow cylinders of different sizes and of large caliber (Fig. 3529), short enough not to push down the membrane and long enough to reach below the cricoid constriction. They have no retaining swell and it is therefore necessary to use the largest size possible, wedging it into the larynx. On no account should these tubes be left in position for more than a few hours, as the pressure caused by them will do great damage to the larynx.

Granulation tubes (Fig. 3526, No. I.) are constructed for cases in which previous intubation has caused the formation of granulation tissue about the larynx. They differ from the ordinary tubes in having a large built-up head, which rides above the granulations and by pressure tends to hasten their absorption. The tube is of all-metal construction giving it greater weight. These two special tubes are seldom made use of at present.

With the exception of the short tube of Bayeux, which possesses the sole advantage of being better adapted to the operation of enucleation or removal by pressure through the trachea, it is unnecessary to mention here any of the so-called modifications of O'Dwyer's instruments, many of which have been discarded as useless and all are totally unnecessary. The O'Dwyer instruments, as made by a reliable manufacturer, meet all the requirements for which they were intended.

The vast majority of cases requiring intubation are due to laryngeal diphtheria. Other conditions rarely requiring the operation are pseudodiphtheria (streptococcus) of the larynx, catarrhal laryngitis, and laryngismus stridulus, primary or secondary, especially to measles.

When to Intubate.—With the use of antitoxin it is the physician's duty to delay operation as long as possible in the hope that the action of antitoxin may do away with the necessity for the operation. Steam and sedatives should be used as adjuvants to the same end. The instruments should be ready, however, and the patient closely watched.

When air hunger has reached such a point that the patient's struggles to overcome it only cause

Fig. 3530.—Feeling for the Epiglottis. The introducer will be parallel to the patient's body as the tube enters the mouth

greater bodily weakness, it is useless to delay operation.

The symptoms calling for operation are progressive dyspnea, labored breathing and cyanosis, retraction of the tissues about the epigastrium and clavicles, diminished respiratory murmur over the lung bases, physical depression, and a failing pulse.

Technique of the Operation.—Intubation may be performed with the patient in either the upright or the dorsal position; the latter is now generally preferred, as there is less struggle on the patients part, and less help is required. The patient is wrapped in a sheet or light blanket from a point just below the shoulders downward, the hands and feet being perfectly restrained by pulling the wrapping tightly about the body and fastening with large safety pins. Care should be taken to avoid a bulky roll over the upper chest as the handle of the introducer is thus interfered with at the time of beginning the operation. A nurse or other assistant stands behind the patient and steadies the head by holding it between the open palms—the

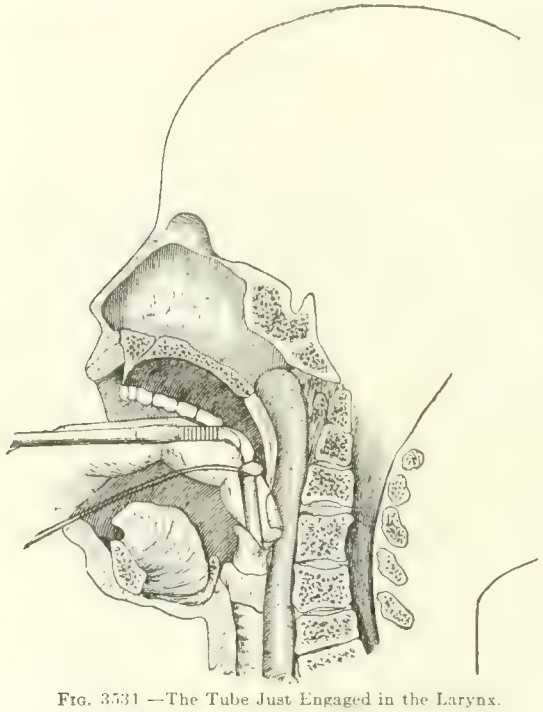


Fig. 3531.—The Tube Just Engaged in the Larynx.

left hand holding the handles of the mouth gag flat against the cheek; another assistant may hold down the legs, but this is not absolutely essential unless the patient is very intractable (see Fig. 3530).

The operator standing at the left side of the patient, inserts the mouth gag well back between the jaws of the left side, opens the mouth widely, and gives the handle of the instrument to the assistant to hold as just described. A tube of the proper size having been selected and its eye threaded, preferably with braided silk, care is taken to see that it slips easily from the obturator, which has been previously fitted to the introducer. The operator then inserts his left index-finger into the patient's mouth, hooks back the epiglottis, crowds the finger as much as possible to the left and passes the tube, in the middle line of the tongue along it, and just under its edge until the tip of the tube engages in the glottis (Fig. 3531). The handle of the introducer is at first nearly parallel to the patient's body; as the tube approaches the larynx, the handle is gradually raised until the tube actually engages in the chink of the glottis, when the elevation of the introducer should be abrupt so that the tube points directly down the trachea. By gentle pressure it is passed downward until the introducer lies crowded against

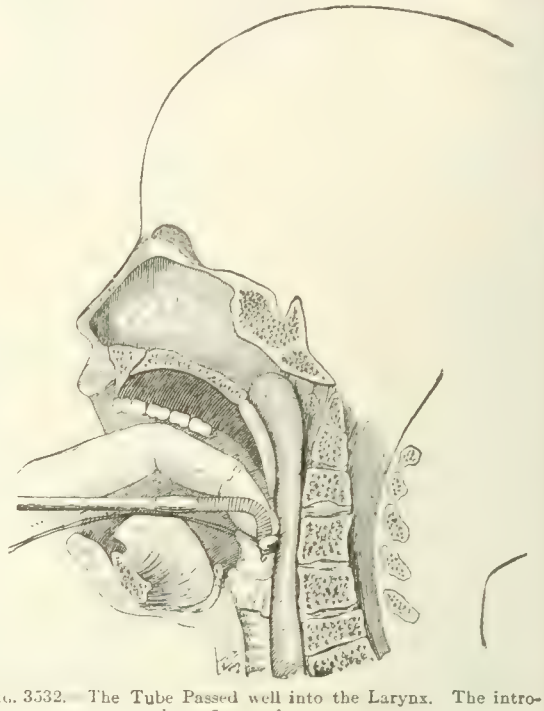


Fig. 3532. The Tube Passed well into the Larynx. The introducer flat on the tongue.

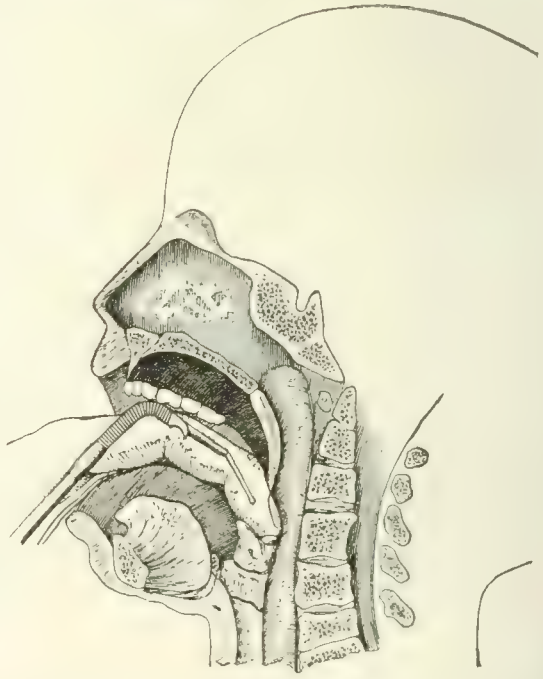


Fig. 3533.—The Left Forefinger Thrusting the Tube in Place and Holding it until the Obturator is Released and Removed from the Mouth.

the tongue (Fig. 3532). The left forefinger is then taken from the epiglottis and placed on the head of the tube, which with a gentle thrust it pushes home at the same time that the obturator is released and

withdrawn from the mouth (Fig. 3533). The left forefinger and gag are then removed. The whole movement of the introducer should be a revolution of a radius of a circle about the opening of the larynx as a center. The removal of the obturator from the tube is the exact reverse of the movement.

The characteristic respiratory sound, cough, and expectoration, together with immediate relief from the dyspnea, indicate that the tube is in position. The string is left in for a few minutes to make certain that the caliber of the tube is free from obstruction by loose membrane or thick mucus, after which one end to its extreme end, which marks the posterior boundary of the glottis in the median line, and the handle of the extractor is abruptly elevated, with the result that the beak of the instrument is pried forward from the finger tip into the opening of the tube. If difficulty is experienced with this method of extraction, the tube may be removed by the same method employed in introducing it, *i.e.* the extractor is passed along and under the index finger, which is holding back the epiglottis.

Care should be taken to regulate the degree of opening of the jaws of the extractor by means of the

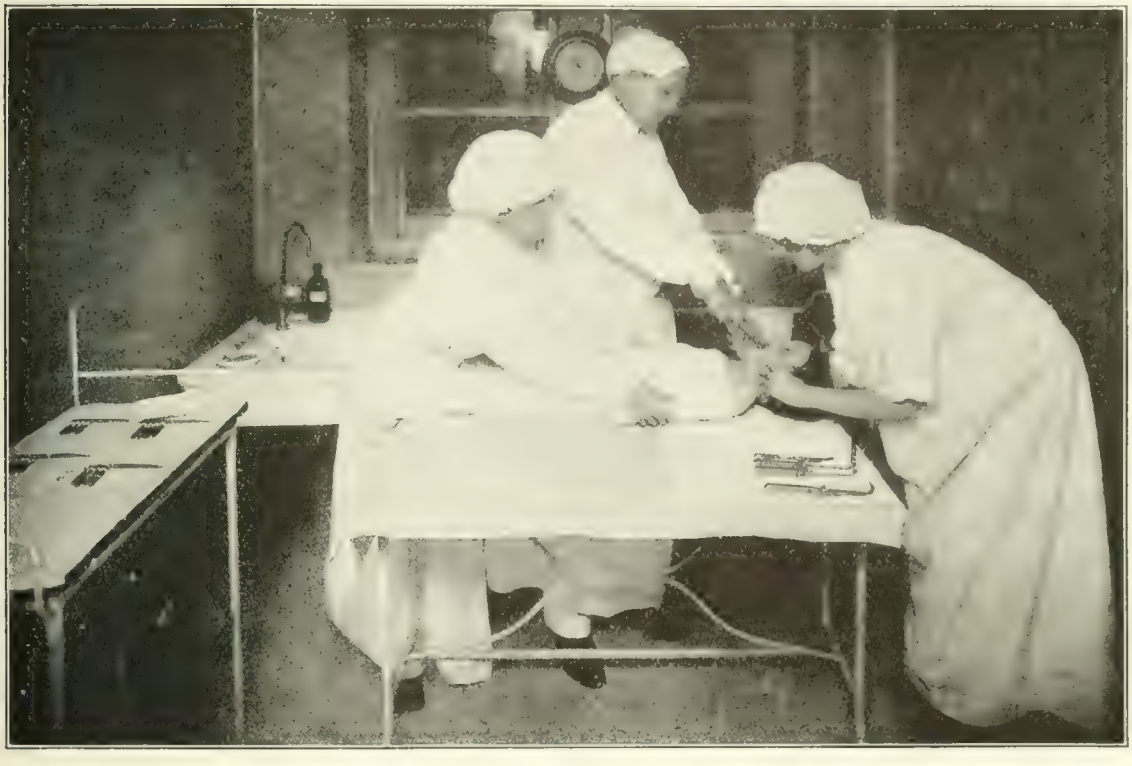


Fig. 3534.—Extubation.

of it is severed close to the angle of the mouth, and while the left forefinger holds the tube in place it is quickly pulled out. It is not necessary, as a rule, to insert the mouth gag for this purpose. In infants, the string may be left in place during the entire period of intubation. In such a case it is to be fastened to the cheek by a bit of adhesive plaster. In older children it causes annoyance, may be pulled on with consequent removal of the tube, and is very apt to be severed by the back teeth. The points to be emphasized in the operation are, in brief: Hold the introducer lightly between the thumb and fingers, using no force. Keep the introducer as nearly as possible in the median line. Be sure that the position of the child is correct and that it is held absolutely immobile. See that everything is in readiness before beginning the operation. If not successful in introducing the tube at the first trial, begin all over, making, if necessary, repeated short attempts rather than a single prolonged one.

Extubation.—In the removal of the tube, patient's position should be the same as that adopted for its introduction (see Fig. 3534); the left forefinger is placed on the arytenoid cartilages, the epiglottis is hooked up as the finger passes over it, the beak of the extractor is passed to the center of the pulp of the finger and then guard screw (Fig. 3535, *a*), in order to avoid laceration of the tissues by their wide separation, during ineffectual attempts to find the opening of the tube. The spring of the extractor should not be touched until the beak of the instrument is engaged in the tube. As in introducing the tube, no force is necessary.

Removal of the tube by "enucleation" has been practised to some extent. The short tubes of Bayeux already referred to are better adapted to this method, although the operation is possible with O'Dwyer's tubes. The child is held head downward, while pressure is made on the trachea just below the point of the tube. This operation, while it is not to be relied upon, especially with the O'Dwyer tubes, is certainly worthy of a trial in an emergency, as for instance when there is a sudden blocking of the tube which is not followed by expulsion. In cases also in which the tube has slipped below its proper position, it is perhaps better to try this method rather than risk pushing the tube farther down with the extractor.

When to Extubate.—With the use of antitoxin, the time during which a tube need be retained has been materially shortened and reintubation is much less frequently required. The retention of the tube is dependent on the general condition of the patient,

the amount of toxemia present, the condition of the pulse and temperature, the presence of membrane in the pharynx, and the age of the patient. Children under two years of age usually require the tube for from one to two weeks, older children for five days or less. As a matter of routine extubation is advisable on the third or fourth day. Blocking of the tube with false membrane or thick mucus is usually an indication for immediate removal. In the majority of such cases the tube is expelled spontaneously.

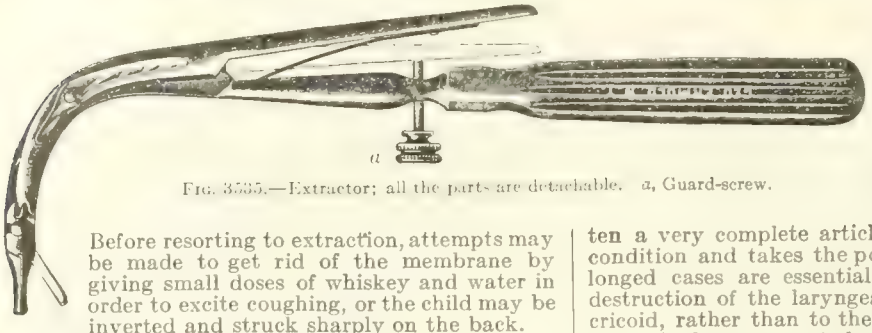


Fig. 3535.—Extractor; all the parts are detachable. a, Guard-screw.

Before resorting to extraction, attempts may be made to get rid of the membrane by giving small doses of whiskey and water in order to excite coughing, or the child may be inverted and struck sharply on the back.

Dangers and Difficulties of the Operation.—There are no dangers to life at the hands of an expert operator from the operation itself. No physician should undertake to intubate a living child without thorough practice on the cadaver. Without such experience, tracheotomy is much to be preferred, for the field of operation is then beneath the eye of the physician. Dangers from the operation in unskilled hands are: asphyxia from prolonged and awkward attempts at intubation, laceration of the soft parts, with the extractor as well as the tube, and the making of false passages, generally through the ventricles of the larynx.

"Pushing down false membrane" has been erroneously held responsible for many deaths during

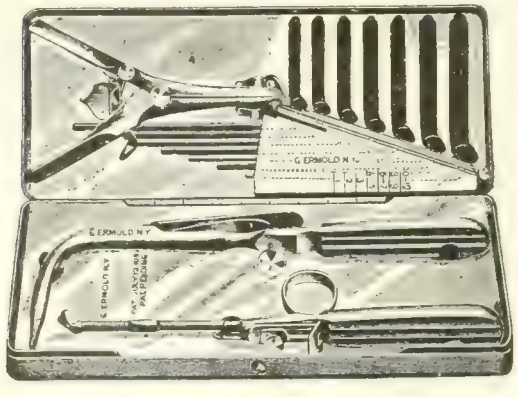


Fig. 3536.—Latest Design of Case Containing a Set of O'Dwyer's Instruments.

the operation. This accident occasionally occurs, in which case the tube should be quickly removed by the still attached string when the membrane will usually be expelled. In some cases it may be necessary to use false membrane tubes for a little while.

Subglottic stenosis (so-called edema) may rarely be the cause of difficulty in performing intubation. This occurs at the cricoid division of the larynx (the narrowest part) and may necessitate a certain degree of force in order to push the tube through the constriction.

Occasionally cases are seen of this nature in which the difficulty is readily overcome by the use of general anesthesia.

Retained Tube.—Chronic Tube Cases.—A small percentage of patients on whom intubation has been performed are unable to go without the tube: Reintubation having to be immediately performed time after time or after hours, weeks, or months. At Willard Parker Hospital there are constantly a dozen or more such patients, some of whom have been in the institution for from three to five years. The causes of this most unfortunate condition are unskillful (rough) intubation and extubation, false passages, ulcerations caused by the disease process, pressure of the tube (especially if the latter be too large for the patient's age), and the use of improperly made tubes. Lynah has written a very complete article on the pathology of the condition and takes the position that the more prolonged cases are essentially due to an erosion and destruction of the laryngeal cartilages, especially the cricoid, rather than to the pressure on and destruction of the recurrent laryngeal nerve. The treatment of these cases is a specialty in itself, each patient requiring especially adapted tubes. Granulations must be healed and polypi removed. Some patients resist every effort to do away with the tube.

Fig. 3537.—Nasal Irrigation; showing the method of wrapping the patient.

Care and Feeding of Intubated Children.—In the majority of cases of intubation the children soon learn to take food in the ordinary way. If, however, this is not possible, Casselberry's position may be necessary at least for a short time. In this method the patient's head hangs back over the lap of the nurse at an angle of forty-five degrees, the feet are elevated on a chair, and food is given with a spoon or from a bottle.

Gavage is preferred by some physicians during the entire time of intubation. It is certainly contrain-

dicated when the pharynx is congested and painful. Rectal feeding should be regarded as a last resort. Semisolids are more easily taken than liquids. Food should be given at short intervals and in such quantities as the child will take.

Nasal irrigation in cases of concurrent nasal diphtheria, is not contraindicated in intubated cases. (See Fig. 3537.) Pharyngeal irrigation had best be omitted. To avoid the necessity of reintubation, Dover's powder, gr. i., or morphine sulphate, gr. $\frac{1}{20}$–$\frac{1}{12}$, may be given a short time before the tube is removed, and repeated afterward if necessary. Other useful measures to the same end are hot poultices over the throat, hot baths, and steam inhalation. Calming and amusing the child are also of great service.

The mortality of laryngeal diphtheria cases in which intubation has been performed (though greatly reduced since the use of antitoxin, is still very high in hospitals, where the deaths, largely from bronchopneumonia, average about one-third of the cases. In private practice, especially under favorable conditions, the death rate is extremely low. Other things being equal, the younger the patient the more serious is the outlook for recovery. Among children under one year in hospitals the prognosis is almost hopeless.

William P. Northrup.
Matthias Nicoll, Jr.

Intussusception.—See *Intestinal Obstruction.*

Inula.—Elecampane.—The root of *Inula helenium* L. (fam. *Compositæ*).

This is a large, rank, perennial herb, with a thick, fleshy rootstock and root, and an upright, branched, hairy or rough stem, from one to two yards high. The lower leaves are half a yard or more long and half as broad. The yellow flower heads are several inches broad, somewhat resembling small sunflowers.

Inula grows, either indigenous or naturalized, in the temperate parts of Europe, Asia, and North America, and is also cultivated in Europe.

The root should be collected either in spring or in autumn, suitably sliced, and dried with gentle heat. It is then "in transverse, concave slices or longitudinal sections, with overlapping bark, externally wrinkled and brown; flexible in damp weather; when dry, breaking with a short fracture; internally grayish, fleshy, slightly radiate, and dotted with numerous shining, yellowish-brown resin cells; free from starch; odor peculiar, aromatic; taste bitter and pungent."

Composition.—*Inulin, helenin, alant camphor, alantol, essential oil, alantoic acid*, waxy, acrid, resinous, and bitter substances, besides ordinary vegetable principles and ash. The first of these, although of no medicinal properties, is the most interesting, and has received its name from this plant. It was discovered in it in 1804 by Valentine Rose, who also pointed out its intermediate position between starch and sugar. Since then it has been observed in the roots of nearly a hundred *Compositæ*, but in the plants of no other family excepting the *Lobeliaceæ*. It has likewise not been found in the aerial portions. The *helenin* is obtained by boiling the roots with alcohol, filtering, and adding cold water to the filtrate, when the helenin separates, upon standing, in fine needles; or it may be separated by distillation. It is a faintly odorous and nearly tasteless, volatile substance, insoluble in water, but soluble in ether, oils, and hot alcohol. The *oil* is a yellow liquid of mint-like odor, and contains alantol ($C_{10}H_{16}O$). Alantic acid is a crystalline substance associated with the oil.

Action and Use.—Although an old remedy, it can hardly be said that elecampane has any important place in modern therapeutics. It is a stimulant, stomachic tonic, and enjoys a slight reputation in the treatment of amenorrhea and bronchitis. Dose, ʒss.–i (2.0–4.0) in decoction of infusion. W. P. Bolles.

Inulin ($C_6H_{10}O_5$) is a polysaccharide which may be obtained as a white, tasteless, odorless powder from the tubers of the artichoke or dahlia. It is difficultly soluble in cold water but quite easily soluble in hot water. In alcohol stronger then sixty per cent. it is insoluble. With iodine it gives a negative reaction. Inulin turns the plane of polarized light to the left and by hydrolysis with acids or with the enzyme inulase it is converted into levulose. The usual amylolytic enzymes of the animal body are without action on inulin. F. P. U.

Inversion.—The transformation of a molecule of cane sugar by the addition of a molecule of water into a mixture of one molecule of dextrose and one molecule of levulose is called inversion. The reaction occurring follows and may be induced by bacteria, enzymes, or dilute mineral acids.

$$\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}} + H_2O = \underset{\text{Dextrose}}{C_6H_{12}O_6} + \underset{\text{Levulose}}{C_6H_{12}O_6}$$

F. P. U.

Invertase is the named applied to an enzyme, widely distributed in nature, capable of transforming sucrose, or cane sugar, into a mixture of dextrose and levulose. This mixture is called invert sugar. (See *Inversion.*) F. P. U.

Invert Sugar.—See *Invertase.*

Iodides.—I. General Medicinal Properties of Iodides.—Iodides whose basic radical is sufficiently innocent to permit of the taking of the salt in decided quantity show special and marked physiological and therapeutic powers, unquestionably due to the iodine of their composition. Physiologically, they tend to produce symptoms as of catarrh, affecting sometimes the mucous membranes of the head alone, and sometimes also the gastrointestinal mucous tract; to bring out an acneform eruption on the face; and, when given in large doses long continued, to favor emaciation. These derangements, constituting the condition known as *iodism*, present themselves clinically as follows: The subject experiences the general feeling of discomfort preceding feverishness, and soon follow running at the nose and watering of the eyes, with frontal headache and sneezing. In sensitive persons the conjunctiva may be blood-shot, and the circumjacent tissues swollen and edematous. A salty taste is perceived, and the salivary flow is somewhat freer than usual. From extension of the influence to the lower mucous membranes, there may develop cough, with hoarseness, from irritation of the throat, and epigastric sinking, with nausea, and a watery diarrhea with colic, from affection of the gastrointestinal tract. An eruption, like acne, is apt to break out, first upon the face, where the papules are generally large and indurated, and later upon the trunk or extremities. Sometimes purpuric blotches also appear, a blebs, and sometimes the main eruption is eczematous instead of acne form. Nervous symptoms are not so very uncommon, of the general type of listlessness and depression, and in one case of long-continued heavy dosage H. C. Wood observed the subject to be "intensely sleepy and stupid," as in the allied condition of bromism. As regards the tendency to emaciation, this certainly is insignificant, even in the very large dosage with iodides of current medical practice; and the alleged atrophy of the mammæ or the testicles under the influence of the iodides, if it happens at all, is so exceedingly rare that it may be dismissed from consideration as a possible danger in the use of the medicines. An important point in connection with the phenomena of iodism is the very different susceptibility of different individuals, on the one hand, and of the same individual at different times,

on the other. Thus, with some, coryza is developed by doses of only a few centigrams each (between one and two grains), and, with some, the disagreeable symptoms spontaneously subside, even during a continuance of the medication. In persons who are keenly susceptible, the necessary therapeutic dosage may be attained by beginning with very small doses, such as 0.03 gram (half a grain) of an alkaline iodide, and gradually increasing. Under any circumstances, the taking of copious draughts of fluid during the course of the medication tends to lessen both the frequency and severity of possible iodism doubtless by hastening the elimination of the iodide salt. And even when occurring, the phenomena of iodism are, with rare exceptions, distressing rather than dangerous, and disappear promptly and fully upon discontinuance of the dosing.

The therapeutic power of the iodides resides in a tendency to promote the absorption of inflammatory or hyperplastic products. This influence, however, proves to be of very different degrees of potency in the different circumstances where morbid products develop. It is, in general, most powerful where the parts involved belong to the nervous or the connective-tissue structures, and, in particular where the process is determined by the syphilitic, the rheumatic, or the scrofulous cachexia. Over purely idiopathic hyperplasiæ or inflammatory products the resolvent power of the iodides, though often decided, and sufficiently so to be exceedingly valuable clinically, yet is distinctly less pronounced. In affections of epithelial structures, the influence of the iodides is perhaps most marked in bronchocele, and much more so in the idiopathic variety than in that belonging to Basedow's disease; next in scrofulous enlargement of the lymphatic glands; and least in enlargement of the spleen and organic disease of the kidney. To develop the full potency of the iodides it is necessary, more often than not, to give large doses, especially in organic disease of the nerve centers, whether syphilitic or idiopathic. In such cases a marked alleviation of symptoms, or, in possible instances, even a cure, may often be wrought by bold exhibition of an iodide, where previous inadequate dosage had failed to produce any effect whatsoever. In brain disease such quantites as from ʒij.–vi. (8.0–24.0) of an alkaline iodide are not unusual daily allowances. Besides the foregoing, iodides have a few special medicinal applications, as follows: In chronic poisoning by mercury or lead, the alkaline iodides, taken internally, tend to determine a reabsorption into the blood, in soluble condition, of such of the mineral as had been fixed in the tissues. Thus elimination of the poison is favored; but thus also acute poisoning may be reëstablished, if too much of the metallic compound is made to enter the blood at once. Hence, in this particular therapeusis of the iodides, the doses must at the beginning be small, and any increase is to be made gradually and with careful watching of the effects produced.

II. The Iodides Used in Medicine.—The iodides official, or entering into the composition of pharmaceutical preparations official in the United States Pharmacopœia, are, of the heavy metals, the iodides severally of *mercury*, *zinc* and *lead;* of the metals of the alkalies and the earths, the iodides of *potassium*, *sodium*, *ammonium*, and *strontium;* and of nonmetallic elements, the iodides of *arsenic* and of *sulphur*. Of these various iodides, those of the alkali metals and of strontium alone can be given in sufficient dosage to develop the full iodide therapeutic influence. In the other iodides the medicinal effects of the basic radical practically outshine what can be gotten from the iodine, and such of the list given above as are compounds of heavy metals or of nonmetals will therefore be found discussed under the several titles of the basic elements. The group of iodides medicinally important simply as iodides comprises, of the official list, only the potassium, sodium, ammonium, and strontium salts, to whose action alone the foregoing remarks concerning effects and uses apply in full.

Potassium Iodide, KI. The salt is official as *Potassii Iodidum*, Potassium Iodide. It occurs in "colorless, transparent, translucent, or opaque white cubical crystals or a white granular powder, having a peculiar, faint, iodine-like odor, and a pungent, saline, afterwards bitter taste. Permanent in dry air, and but slightly deliquescent in moist air. Soluble in 0.7 part of water, and in about 12 parts of alcohol at 25° C. (77° F.); in 0.5 part of boiling water, and in 6 parts of boiling alcohol; also soluble in 2.5 parts of glycerin" (U. S. P). The salt should be kept in well-stoppered bottles. Potassium iodide is chemically incompatible with metallic mercury and the pharmaceutical preparations containing mercury in that state, and with the oxides, sulphates, and chlorides of the same metal, including mercurammonium chloride ("white precipitate"). In the case of mercuric chloride (corrosive sublimate), however, the chemical incompatibility does not impair the medicinal efficiency or pharmaceutical elegance of a mixture of the two salts in solution; for if, as must be the case in a medicinal prescription, the potassium iodide be in excess, the mercuric iodide forming upon addition of mercuric chloride immediately redissolves through the secondary forming of a double salt. And such solution produces to full degree the medicinal effects of the mercurial. Corrosive sublimate therefore may be prescribed very conveniently in a solution of potassium iodide. Potassium iodide is incompatible with alkaloids, and practically so also with potassium chlorate; for though no reaction occurs at ordinary temperatures when potassium iodide and potassium chlorate alone are mixed, yet upon the addition of a mineral acid iodine is liberated and apparently iodic acid is formed in the solution. And, according to Melsens, the giving to dogs of potassium iodide and chlorate in conjunction leads to speedy, and even possibly fatal, poisoning, presumably because of the occurrence of some such reaction as just described.

Potassium iodide is the best known and most used of the alkaline iodides, and is commonly considered the most effective one of the group. Being a salt of potassium, and one given medicinally in large doses, it produces, in addition to the typical effect of the iodides, those peculiar to potassium salts as such. Accordingly, full doses may depress, generally, and in particular, may weaken heart action: may be diuretic, and, if swallowed in strong solution, be decidedly irritant to the stomach. As regards the diuretic effect, upon which much stress is often laid, this occurs to about the same degree as with other potassium salts, such as the citrate or acetate (see *Potassium*), a degree which, though not very pronounced, yet may lead to valuable clinical results; for the diuresis often will favor the resolvent effect of an iodide, so that, where dropsy is a feature of a case for which an iodide is to be prescribed, the potassium salt is peculiarly the one to be selected. As to the gastric irritation apt to follow large doses of potassium iodide, this is a well-recognized feature of the action of the salt if the same be given in strong solution; but by the simple device of making the solution quite dilute, this and also all other symptoms of iodism are rendered much less likely to occur.

Potassium iodide is absorbed and eliminated rapidly, and is available for all the purposes of the iodides as set forth in the first section of this article. As to dosage, it is rare that any useful effect follows a smaller daily allowance than gr. xv. (1.0); generally, indeed, from two to three times such quantity will be necessary; and very often—notably in organic affections of the central nervous system—the daily quantity must be pushed rapidly to a range between two and six drams (8.0 and 24.0), else a valuable, possibly

even curative effect will wholly be missed. In all cases the daily allowance should be broken up into at least three doses; and, especially where the quantities are large, the precautions of giving the salt in an abundance of fluid, and also of giving frequent draughts of water during the whole period of the medication, should be carefully observed. An alkaline vehicle is the best, and is decidedly preferable to the syrupy mixtures so often prescribed; and such other medicines as may also be indicated in a given case are best administered by themselves at different times from the iodide. The United States Pharmacopœia makes official *Unguentum Potassii Iodidi*, Ointment of Potassium Iodide, containing ten per cent. of the salt incorporated in benzoinated lard. The ointment is designed for the local treatment of surface indurations.

Sodium Iodide, NaI. The salts is official as *Sodii Iodidum*, Sodium Iodide. It occurs as "colorless, cubical crystals, or a white, crystalline powder, odorless, and having a saline and slightly bitter taste. In moist air sodium iodide deliquesces and frequently undergoes decomposition, the salt assuming a brown tint. Soluble in about 0.5 part of water, and in about 3 parts of alcohol at 25° C. (77° F.); in 0.33 part of boiling water, and in 1.4 parts of boiling alcohol" (U. S. P.). The salt should be preserved in well-stoppered bottles.

Sodium iodide bears to the potassium salt the usual relation of a sodium to a potassium chemical brother. It is less depressing, less irritating, and less diuretic, but also, though efficient enough in ordinary cases, is less reliable in those cases that test medicinal potency most severely. The salt is to be given in the same doses as potassium iodide, and with the observance of the same precautions.

Ammonium Iodide, NH_4I. The salt is official as *Ammonii Iodidum*, Ammonium Iodide. "It occurs as minute, colorless, cubical crystals, or a white, granular powder, without odor when colorless, but emitting a slight odor of iodine when colored, and having a sharp, saline taste. The salt is very hygroscopic, and soon becomes yellow or yellowish-brown on exposure to the air and light, owing to the loss of ammonia and the elimination of iodine. Soluble in 0.6 part of water and in 9 parts of alcohol at 25° C. (77° F.); in 0.43 part of boiling water, and in 3.7 parts of boiling alcohol. When heated on platinum foil, ammonium iodide evolves vapor of iodine and volatilizes completely without fusing" (U. S. P.). From the proneness of this salt to deliquesce and to generate free iodine, the Pharmacopœia enjoins that it be kept in small, well-stoppered bottles, protected from light, and that samples deeply colored be not dispensed until deprived of free iodine by proper treatment.

Ammonium iodide exhibits the usual properties of the iodides, and may be used for the usual purposes. As usual, contrasting ammonium with potassium salts, the ammonium is less depressing than the potassium, but is inconvenient because of its readiness to decompose with the objectionable evolution of free iodine. Ammonium iodide is generally prescribed in smaller dosage than the potassium salt, the daily average being from gr. xv.–xxx. (1.0–2.0). It should be given in plenty of fluid, and the solutions should not be kept too long, and while kept should be well protected from light.

Strontium Iodide, $SrI_2 + 6H_2O$. The salt is official as *Strontii Iodidum*, Strontium Iodide. It occurs in "colorless, transparent, hexagonal plates, odorless, and having a bitterish, saline taste. Deliquescent, and colored yellow by exposure to air and light. Soluble in about 0.5 part of water at 25° C. (77° F.), and in 0.27 part of boiling water. Also soluble in alcohol and slightly soluble in ether" (U. S. P.). The salt should be kept away from the light, in dark amber-colored, glass-stoppered vials.

Strontium iodide acts like the iodides of the alkalies, but is more slowly absorbed, and is believed to have less tendency than the potassium iodide to irritate the stomach or intestines. It is given in solution, in doses ranging from gr. v.–xv. (0.3–1.0).

EDWARD CURTIS.
R. J. E. SCOTT.

Iodine.—See *Iodum*.

Iodipin is an addition product of sesame oil and iodine, and has an action similar to that of the iodides. It is claimed, however, that iodipin is not so likely to cause iodism, and also that its action is more lasting.

R. J. E. SCOTT.

Iodoform.—Iodoform, chemically *triiodomethane*, or *methenyl iodide*, CHI_3, is official in the United States Pharmacopœia as *Iodoformum*, Iodoform. It is prepared in a variety of ways, in which the essential reaction is between alcohol and free iodine with the resulting formation of iodoform. Iodoform occurs as "a fine, lemon-yellow powder or lustrous crystals of the hexagonal system, having a peculiar, very penetrating, and persistent odor, and an unpleasant, slightly sweetish, and iodine-like taste. Soluble in 9,391 parts of water, to which it imparts its odor and taste, in 46.7 parts of alcohol, and in 5.2 parts of ether at 25° C. (77° F.); soluble in about 12 parts of boiling alcohol; soluble in chloroform, and fixed and volatile oils, slightly soluble in petroleum benzin" (U. S. P.). Iodoform volatilizes somewhat even at ordinary temperatures, and on heating first melts to a brown liquid, and then gives off iodine vapors, with a residual carbonaceous mass, which finally is wholly dissipated. Iodoform should be kept in well-stoppered bottles in a cool place. The *odor* is peculiar not only in quality, but also in the fact that it is very penetrating and persistent, and that a very little of the substance will develop the smell in full strength. To many persons the odor is positively offensive, while to others it is quite unobjectionable. Concerning the solubilities of iodoform, it should be noted that a very common text-book error is the unqualified statement that the substance is "soluble in alcohol," leading to the inference that it is freely so, whereas, as a matter of fact, it is but sparingly soluble in cold, and only moderately soluble in boiling, alcohol (see above).

Locally, iodoform tends to benumb, to repress suppuration and other unhealthy action, and to promote healing. In tuberculous disease, as in cases of tuberculous abscess, the latter effect is marked. This healing virtue of iodoform probably results partly from absorption by the powder of the juices of the exposed part, and from mechanical protection, and partly from the action of free iodine liberated through decomposition of the iodoform. Such decomposition readily occurs when iodoform meets with alkaloidal or albuminous fluids. Formerly the virtues were thought to be due to a germicidal action, but it is now shown that iodoform as such has little or no direct power either to kill pathogenic microorganisms or to hinder their development.

Iodoform can be absorbed into the system, not very readily from the stomach, but quite so from fresh wound surfaces, and in such cases a certain amount, at least enters the blood unchanged. It is excreted mainly by the kidneys and in the form of iodides, but also is to be found in the saliva, the bronchial mucus, and the perspiration. Swallowed in quantities of five or six grains it is harmless, but when extensively applied to absorbent wound surfaces it is capable of producing serious and even fatal constitutional poisoning. (See section on Toxicology.)

Iodoform has been tried as an internal medicine in the place of the alkaline iodides, especially in syphilis, but without striking results. The dose is gr. i. to iij. (0.06–0.2) three times a day, preferably in pill, in order that the odor may be concealed. Ex-

ternally, iodoform is a good anodyne application to painful surface affections of all kinds, and is specifically healing, especially in syphilitic lesions and in local tuberculous affections. Also it makes an excellent dressing for wound surfaces, and is accordingly extensively used by the operating surgeon. It may be applied dry (finely pulverized, so as to obviate the mechanical irritation by the edges of the crystals), by dusting from a dredger, and then covering the dressed surface with cheese-cloth, lint, or absorbent cotton; or an iodoformized gauze may be used. Such gauze may be prepared by rubbing powdered iodoform into the meshes of the material, or the latter may be soaked in an ethereal solution of iodoform which, by drying, leaves a fine powder of the drug evenly diffused through the texture of the fabric. Care should be taken not to risk poisoning by packing considerable quantities in tightly closed wound or abscess cavities. As a healing dressing, the official preparation may be used, entitled *Unguentum Iodoformi*, Iodoform Ointment, which consists of iodoform, ten per cent., thoroughly incorporated with lard. In the local treatment of tuberculous abscesses a ten per cent. emulsion in sterilized oil or in glycerin has been much used. These same emulsions have also been injected into the substance of tuberculous glands which have not undergone suppuration. To mask the diffusive and persistent smell of iodoform, the addition of a great many substances has been proposed, of which substances some, such as the Tonka bean and the more powerfully odorous of the volatile oils, simply overwhelm the smell of iodoform with their own odor, and are hence unobjectionable. A bit of Tonka bean may be kept in the iodoform bottle, or one part of oil of bergamot, peppermint, spearmint, or gaultheria may be added to twenty parts of iodoform (Hager). Tannic acid and balsam of tolu, two substances suggested for the present purpose, act by chemical attack upon the iodoform, and hence are not to be recommended. It has been suggested that vinegar will remove the odor of iodoform from the hands.

Related Compounds.—Because of the offensive smell of iodoform and the occasional poisoning by the medicine, many substitutes have been sought in related compounds. Of these the following deserve mention:

Iodol, tetraidopyrrol, C_4I_4NH. This compound is formed by the action of iodine on pyrrol, and occurs as a yellowish-brown, crystalline powder, without taste or smell, insoluble in water, but soluble in alcohol and, though less readily, in ether, chloroform, and the fixed oils. It contains 88.9 per cent. of iodine.

Iodol, though insoluble in water, is capable of absorption by the living animal tissues, and so produces constitutional effects on administration by the mouth. In experiments on animals it has caused emaciation and albuminuria, with muscular weakness and lowering of temperature, and, finally, death from fatty degeneration of the kidneys and liver. Constitutional effects have followed also the local use of the compound in surgery, but, owing to the comparative slowness of absorption of iodol, it is less apt to produce untoward effects than is the case with iodoform.

Iodol is available for all the uses of iodoform. It may be applied locally in powder or in alcoholic solution. A collodion preparation of iodol may be made by dissolving one part of iodol and five of guncotton in ten parts of ether.

Iodol has been given internally in diabetes and in tertiary syphilis, in doses of from gr. ij.–iij. (0.13–0.2).

Losophan, triiodometacresol, $C_6HI_3(OH)(CH_3)$. This substance, a compound of iodine and cresol, occurs in colorless needles, odorless, insoluble in water and nearly so in alcohol, but freely soluble in ether, chloroform, and the fixed oils. The crystals contain 78.39 parts of iodine and melt at 121.5° C. (250.5° F.).

Unlike iodoform, losophan does not yield free iodine on contact with the animal tissues, and so cannot truly substitute iodoform in medical practice. It has been used as a local antiseptic, but with questionable advantage. It may be applied in a one- or two-per-cent. solution in alcohol and water (alcohol three parts, water one part), or in an ointment of from one to ten per cent. strength, with basis of vaseline or a mixture of vaseline one part, and lanolin four parts.

Nosophen, tetraiodophenolphthalein $(C_6HI_2OH)_2COC_6H_4CO$. This compound, behaving as an acid, occurs as an impalpable, pale yellowish powder, odorless and tasteless, insoluble in water and difficultly so in alcohol, ether, and chloroform, but soluble in alkalies, with which substances it combines to form salts. Nosophen contains 61.7 per cent. of iodine.

Like losophan, nosophen does not yield iodine on contact with the animal tissues. It has been used, however, for the purposes of iodoform, and is unirritating and non-poisonous. It may be applied freely in its powder form.

The sodium salt of nosophen has been used in medicine under the name of *antinosine*. This salt occurs as a dark blue amorphous powder, and is freely soluble in both water and alcohol. It may be used for local antiseptic purposes in solutions varying in strength from one to three per cent., which solutions are without odor or taste.

The bismuth salt also has been used under the name of *eudoxine*. This substance is a reddish-yellow powder, tasteless and odorless, and insoluble in water. It is decomposed by alkalies with the formation of antinosine. It has been given internally, for gastro-intestinal derangements, in doses of from gr. ss.–viij. (0.03–0.5), and is assumed to undergo conversion into antinosine by the action of the alkalies in the intestinal fluids.

For *europhen*, see article under its own title.

Toxicology.—The smallest dose known to have produced toxic symptoms is less than one grain. The smallest *fatal* dose is probably about forty-five grains. Fatal results from doses of one dram and upward have been reported. But, on the other hand, a case has been recorded in which a woman took two drams of iodoform at a single dose, with no worse result than severe headache, griping pains in the abdomen, and purging; but the odor and taste of the drug remained for several days.

It must be borne in mind (1) that many toxic effects may have been due to impurities in the drug; (2) that some people are particularly susceptible to iodoform, and many cases of iodoform poisoning are due to idiosyncrasy; (3) that iodoform seems particularly dangerous in wounds and injuries of the breast, axillary space, and chest wall, and therefore great care should be taken in using the drug in these regions.

Symptoms.—The cause of the toxic symptoms is the iodine. Iodoform (CHI_3), which contains more than ninety-six and one-half per cent. of iodine, is decomposed by the tissues with which it comes in contact, and iodine is liberated. This free iodine promptly combines with the albumin of the tissues, and the result is an unstable albuminate of iodine, which passes into the circulation and thence to the various organs of the body.

Cases of poisoning by iodoform may be divided into two main groups: (1) Local, cutaneous, or eruptive. (2) General or constitutional: (*a*) with cerebral symptoms; (*b*) with coma.

1. *Local, Cutaneous, or Eruptive.*—This is the commonest form and generally follows the application of iodoform as a dressing. There is a dermatitis of an erythematous type, or an eczematous eruption. The part is swollen and is covered by many small thick-walled vesicles. These vesicles become confluent and are filled with a serous fluid which may later become tinged with blood. The epidermis is at first raised;

later it peels off, and leaves an exposed area of very sensitive corium bathed in a serous exudate.

2. *General or Constitutional* (*a*) *with Cerebral Symptoms.*—This may occur some time after the application or injection of the iodoform, or almost immediately. The symptoms are the odor of iodoform in the breath; yellow discoloration of the skin and conjunctivæ; increase of temperature; pulse small, irregular, and rapid (up to 160 or 180); faintness, vertigo, severe headache, thirst, nausea, vomiting, gastrointestinal irritation, muscular twitchings; the patient becomes melancholic and has delusions of persecution and possibly suicidal tendencies, hence must be carefully watched; there is maniacal excitement, which may subside on removal of the dressing. "There is nothing specific in iodoform mania; it may occur with the first dressing, or it may result from its prolonged use; it gives rise to restlessness, to sleeplessness, to irritability passing into mania, and the mania may rapidly give place to stupor or mental weakness" (Savage, in Allbutt and Rolleston's "System of Medicine," 1911, vol. viii., p. 909). Barois found in severe cases that the symptoms came on suddenly and early; first mental depression, then excitement.

(*b*) *With Coma.*—This is the most severe form. The pulse is rapid and feeble; there is rigidity of the neck, as in meningitis; great mental confusion with misplacing of words; there may be paralysis of the sphincters; the patient becomes emaciated, lethargic, and falls into a state of coma and dies.

Death occurs from paralysis of the heart. Age increases the susceptibility of most persons to the action of the drug. Tuberculous and cachectic patients are said to give worse results than others; but probably iodoform is more often administered to these patients than to others.

Pathology.—The postmortem findings are fatty degeneration of the heart, liver, kidneys, and muscles; hyperemia of the meninges and some atheromatous lesions of the arteries. Barois found occasionally a partial infiltration of the lungs, with degeneration of the alveolar epithelium.

The *prognosis* is bad. It probably depends upon idiosyncrasy as well as dose.

Prophylaxis.—Get a pure preparation of the drug; use as small an amount as possible; remember idiosyncrasy; be particularly cautious in wounds of the breast, chest walls, and axillary space.

Treatment.—In every case stop the application of further iodoform; then keep up the patient's strength and remove as much as possible of the drug with water, a warm solution of starch, oil of eucalyptus, or ether and cotton; and give diuretics, diaphoretics, and a hot bath to hasten elimination. Apply dressings of decinormal salt solution, snip off the top of any vesicles that may be present, so that the solution may reach the corium underneath; locally apply some non-irritating alkaline fluid to neutralize the nascent iodine, and thus prevent its entering into combination with the albumins. Give stimulants, and to increase the alkalinity of the blood administer potassium acetate, potassium bicarbonate, or potassium bromide; this latter is recommended, and may be administered in an initial dose of gr. xv. in ʒij. of water, followed by gr. x. every hour. R. J. E. Scott.

Iodum.—Iodine is official in the United States Pharmacopœia as *Iodum*, Iodine. It is described as "heavy, bluish-black, dry and friable, rhombic plates, having a metallic luster, a distinctive odor, a sharp and an acrid taste. . . . Iodine imparts a deep-brown evanescing stain to the skin, and slowly destroys vegetable colors. Soluble in about 5,000 parts of water, and in ten parts of alcohol at 25° C. (77° F.); freely soluble in ether, chloroform, or carbon disulphide; its solution in alcohol or in aqueous solution of potassium iodide has a reddish color; its solution in chloroform or carbon disulphide has a violet color" (U. S. P.). Iodine volatilizes slowly, even at ordinary temperatures, and, upon heating, melts and is dissipated, without residue, in violet-colored fumes. With starch paste it produces a characteristic dark blue color. Iodine must be kept in glass-stoppered bottles, in a cool place. The commercial sources of iodine, at the present time, are mainly the native beds of sodium nitrate in South America, where sodium iodate occurs in association with the nitrate salt. Some iodine, however, is still prepared from kelp—the ashes of burnt sea-weeds.

Iodine, like its chemical congeners, chlorine and bromine, has an affinity for hydrogen, but its action, because of this affinity, in decomposing compounds containing hydrogen is not so pronounced as in the case of chlorine or of bromine. Probably, mainly because of this affinity for hydrogen, vapor of iodine is deodorant, and iodine solutions applied directly to foul and infectious matter prove both deodorant and disinfectant. Sternberg, experimenting with the micrococcus of gonorrheal pus, found iodine to be antiseptic (*i.e.* inhibiting development) in solutions of the strength of one part to four thousand (one-fortieth per cent.), and permanently germicidal in solutions representing one part to 500 (one-fifth per cent.)—percentages which, as compared with those of other so-called antiseptics similarly studied, show for iodine a high germicidal potency. As regards the effects of the element upon the living animal system, iodine is locally irritant and even caustic; and taken into the stomach, is readily absorbed and produces constitutional effects similar to those of the alkaline iodides. (See *Iodides.*) Many consider, indeed, that the greater part of a dose of iodine finds entrance into the blood in the condition of sodium iodide. Others hold that probably some, at least, of the iodine enters into combination with albumin, and is absorbed in the state of the compound so formed. The local effects of iodine, which medically are of more importance than the constitutional, are in detail as follows: Applied to the skin, iodine solutions stain the cuticle a yellowish-brown and excite some tingling, pricking, or, if strong, even smarting. The stain tends spontaneously to disappear, and, if the application has not been too strong, some desquamation of the epidermis is the only physiological after-effect. If, however, a strong solution is used, or if repeated applications are made upon the same spot, the skin may inflame and blister, with the production of a very painful sore, or may even be destroyed. In all cases the healing action following the direct effects of the iodine is rapid and kindly. Upon serous membranes iodine easily induces an active inflammation, which, if the application has not been too severe, is almost certainly of the adhesive character, leading to permanent agglutination of the opposing surfaces. Upon mucous membranes, also, iodine solutions produce considerable irritation, and, if swallowed, may cause dangerous, and even fatal, irritant poisoning. But from the pronounced color and taste of such solutions, accidental or criminal poisoning is unlikely, and iodine is not well enough known as a poison to be selected for purpose of suicide. In case of poisoning, substances containing starch should freely be given as the best antidote, and the symptoms treated upon general principles.

An important question is the possibility of absorption of iodine from local surface applications of its solutions. That it can be absorbed by serous surfaces is beyond doubt, since a case has been reported in which fatal poisoning, with constitutional symptoms, followed an injection of an iodine solution into an ovarian cyst. When applied to the unbroken skin, it is possible that, if the solution contain also an alkaline iodide (by whose presence iodine becomes soluble in aqueous fluids), a little iodine may be absorbed; but if a simple alcoholic solution of iodine be employed, theoretical

considerations are certainly against the probability of absorption. It is most probable, therefore, that what therapeutic effects follow from painting the skin with tincture of iodine occur simply as reflexes of the local irritation.

The constitutional effects of iodine are substantially similar to those of the alkaline iodides. The main point of difference is, as might be inferred, that iodine will cause more gastrointestinal irritation than will the iodides. The alleged occasional atrophy of the breasts or of the testicles following prolonged iodizing, in the case of Swiss *cretins*, is also more commonly averred of administration of iodine than of iodides. The therapeutic effects of constitutional iodizing are also similar in kind to those obtained by the giving of iodides (see *Iodides*); but, perhaps more from habit than from any demonstrated advantage, iodine is often preferred to iodides for the treatment of scrofulous affections and of goiter.

Therapeutically, iodine is a possible disinfectant and deodorant for privies and drains, but unfortunately is too costly for any use requiring considerable quantities. An alcoholic solution of iodine is painted on the skin prior to operations; this is as an aseptic precaution. It is also used as an antiseptic in wounds. Applied to the skin, solutions of iodine may be used to destroy life or arrest development of the organisms in parasitic skin disease, such as ringworm, although they are not so powerful for the purpose as mercurials; to set up healthy action in sluggish sores; and, painted in repeated coatings over the sound skin, to operate by ordinary counterirritation for the allaying of pains or for the resolution of engorgements, reabsorption of hyperplasiæ, or abatement of chronic and sluggish inflammations in underlying parts. For the purposes of the latter general category, however, iodine is certainly no better than other agents of equal irritant power; and its selection, because of an assumed specific iodine influence, constitutionally, is futile. To serous surfaces iodine solutions are applied in order to excite adhesive inflammation for the purpose of obliterating a serous tract, as, for instance, in cases of hydrocele, or of spina bifida, or of knee-joint effusion, or even in cases of pleurisy with effusion, or of empyema. But in the case of serous cavities of considerable extent and importance, iodine injections, even when the solutions are fairly dilute, are risky, and many cases are on record of undue irritation, of serious constitutional reaction, and even of death, following such procedures. Internally, iodine is given almost exclusively for its constitutional effects, namely, for the determining of healthier nutritive ways in chronic diseases of nutrition, particularly those of so-called strumous character, and in goiter. Because of the gastric irritation it so easily excites, iodine is not so available for full iodizing as are the alkaline iodides. In the treatment of syphilis, rheumatism, organic affections of the central nervous system, etc.—conditions calling for heavy dosage—the iodides are nowadays quite generally, and quite properly, preferred to iodine.

For use, iodine may be dissolved in alcohol, or, by the addition of potassium iodide, in water or glycerin. "Morton's solution," employed by Dr. Morton, of Glasgow, and others, for injection in cases of spina bifida, consists of ten grains of iodine and thirty of potassium iodide to an ounce of glycerin. Of this, from twenty-five to thirty minims have been injected into the sac in the affection in question. In this country the official preparations are almost exclusively employed, and are as follows:

Tinctura Iodi, Tincture of Iodine. This preparation is a simple seven-per-cent. alcoholic solution of iodine. It should be kept in well-stoppered bottles. Tincture of iodine is a dark-brown, limpid fluid, of a strong odor and taste of iodine. It stains skin and fabrics a rusty brown, and is strong enough of iodine to blister the skin if repeatedly applied to the same area, to inflame serous surfaces, and, swallowed clear, dangerously to irritate the gastrointestinal tract. It precipitates with water, from the very feeble solubility of iodine in that fluid. Because of this fact the tincture is not eligible for internal administration, and its use is limited to local application. For the treatment of skin disease, or for counterirritation, the tincture may be used without dilution, lightly painted upon the part with a camel's-hair brush. If the skin be not too sensitive two coats may be laid on, the second as soon as the first has dried—which result happens in a few seconds, from the speedy evaporation of the alcohol. Such paintings may be renewed in the course of two or three days, but must not be made too often over the same area, else blistering and a painful sore will result. For injection into serous cavities tincture of iodine must be diluted, the degree depending upon the area and importance of the tract to be affected, but ranging from twofold to tenfold. The fluid for the dilution is water, to which, to prevent the precipitation of the iodine, potassium iodide must be added in proportion about equal to sixteen per cent. of the quantity of tincture taken for the mixture. In some cases, as of spina bifida, and even empyema, some practitioners have injected small quantities (♏xxx. to lx.—2.0–4.0) of undiluted tincture of iodine.

Under the title of *decolorized* or *colorless tincture of iodine*, preparations are made in various ways, in all of which the addition of water of ammonia to tincture of iodine is an essential feature. Such preparations are indeed colorless, but they are no longer tinctures of iodine in the sense of containing iodine uncombined, since most of the iodine in these solutions exists in combination with the ammonia as ammonium iodide. The preparation of this character of the German Pharmacopœia is compounded of iodine, sodium "hyposulphite," spirit of ammonia, water, and alcohol. The resulting composition is complex, but the essential ingredient is ammonium iodide.

Liquor Iodi Compositus, Compound Solution of Iodine; Lugol's Solution. This preparation is a joint aqueous solution of iodine and potassium iodide, containing five per cent. of the element and ten of the salt. It must be kept in glass-stoppered bottles. This solution is dark colored and stains like the tincture, but, unlike that preparation, does not precipitate on admixture of aqueous fluids. It is intended for internal taking, and is indeed the only preparation of free iodine ordinarily so administered. The dose is about ♏v. (0.3) several times a day, largely diluted with water.

Unguentum Iodi, Iodine Ointment. This ointment consists of four per cent. of iodine and four of potassium iodide, smoothly incorporated with glycerin and benzoinated lard. The iodine and iodide are first rubbed with a little water, whereby the iodine is more ready to mix with the lard. Iodine ointment should always be made fresh when wanted, since it suffers spontaneous change upon keeping. It is of a deep-brownish color, stains the skin yellow, and exerts thereupon a moderate iodine effect.

Edward Curtis.
R. J. E. Scott.

Ionic Medication; Ionic Surgery.—The Ion.—One of the chief uses of water in the biology of living things is its action in dissociating, or ionizing, as well as dissolving, the salts and other compounds of which living tissues are composed, and with which they are fed by anabolism and cleansed of waste products by catabolism. Deprived of water life is arrested in the tissues as it is in the deserts of the earth's surface. For Arrhenius has shown us that the function of water is not merely that of a solvent of tissues, but that the solvent action on all substances that are electrolytes is accompanied by a dissociation of some of the molecules of the dissolved substance into the two atoms, or

groups of atoms that, electrically united, formed the molecules, the dissociated atoms each taking one-half the total electric quantity that had been absorbed in maintaining the molecule and becoming ions with charges of opposite sign.

A good illustration of dissociation is a pan of water in which a little sodium chloride has been dissolved. It has been found that a considerable proportion of the molecules of the sodium chloride are at once dissociated into sodium ions and chlorine ions, the number of molecules dissociated being increased by the dilution of the solution. If we pass a direct electric current through the solution the sodium ions will move toward the cathode, and are therefore called cations, and the chlorine ions toward the anode, and are called anions.

Now the important fact should be stated here, that an atom in the ionic state, or with its electric charge, does not possess the qualities of an atom as long as it retains its charge. The sodium ion exhibits none of the qualities of sodium, nor the chlorine ion that of chlorine, until they give up their charges on reaching the opposite pole or on passing through chemical interchanges in the electrolyte. Ions are considered to be in continual motion. Moreover, the greater number of the molecules in solution in the fluids of the body are dissociated into ions. The phosphates of the blood, for instance, are in the form of the phosphate ion and the ion of the base. Sodium chloride exists as sodium cations and chlorine anions, and so on. This ionic state of the dissociated molecules of the inorganic salts in solution, as well as, to a lesser extent, the organic salts, is essential to all chemical action within the body as well as outside, and is therefore a necessary part of all physiological and pathological phenomena. It should also be understood that electric currents are conveyed through liquids and solutions by the ions alone. Pure distilled water contains no ions and will not conduct electricity. Rain water, and particularly well waters, contain sufficient dissolved impurities dissociated by the water to become reasonably good conductors. Alcohol has no ions, hence will not conduct currents. Sugar in solution in pure water will also fail to conduct electricity, having no ions.

Action of Electric Currents on the Ions of Body Fluids.—From the above-mentioned facts it is evident that the human body is a microcosm of ionic activities in life, and also during dissolution after death, with innumerable ions vibrating back and forth, each engaged in the chemical actions determined by the cellular heredity and neuron control of its particular environment. An illustration of these multitudinous activities may be given by comparing the body to a great city and the ions to its citizens, all engaged in the many pursuits that go to make up the life of a metropolis.

When an electric current is caused to traverse the fluid and semi-fluid tissues of the body all these activities in its path are accentuated or retarded by the direction of the current in proportion to the current passing. No adequate analogue can be given of such an action on the inhabitants of a city, but it may be imagined as either psychic or material. The degree of disturbance in a given portion of the body is determined by the strength of the lines of current flow through that portion, and as the body electrolyte is, save for its bony or horny constituents, grossly a homogeneous conductor, the lines of flow branch fanlike to all parts of the body from their entrance at the cathode and converge in like manner at the anode, the amount of current conveyed by each line of flow being inversely proportional to its length. That is, if the distance between the poles in a straight line through the body is one-third as long as that around one-half the surface of the body beneath the skin, three times as much current will pass a central point in the middle of the body as will pass a point near the surface midway between the poles.

Polar Action of Body Ions.—Such a current will set all the ions of the electrolyte in motion in a definite direction, the anions toward the anode and the cations toward the cathode, each at a speed peculiar to itself and also determined by the potential of current flow in its immediate vicinity. The speed is of course greatest where the lines converge at each pole because, in broad conductors, the current flow is there concentrated. On reaching the poles the ions give up their charges and revert to free atoms or groups of atoms, attacking the material of the electrode or other atoms of the electrolyte according to the laws of the usual chemical reactions. Such, briefly stated, are the phenomena of electrolysis, for decomposition of the electrolyte necessarily occurs at the poles. These polar reactions of the body electrolyte are made use of in ionic surgery, both as a destructive agency of abnormal growths and hypertrophies and as a means of diffusing into malignant growths the destructive ions produced in the ionization of metals employed as electrodes.

Interpolar Action of Body Ions.—Electrotherapeutists have heretofore supposed that direct currents produce no action in the body tissues at points sufficiently removed from the poles to eliminate the polar action. The latter as just stated, is most definite and readily appreciated by the senses, and is due, as we now know, to the reversion of the ions to free atoms. But the more recent teachings of dissociation normally present in body fluids, and our knowledge of the forced motion given to these body ions by direct currents, opens up a new field of research into possible effects of this forced speed and artificial direction of the ions in the interpolar regions, and the possible actions of such changes of the normal chemical activities on metabolism.

The Addition of Ions to the Body by Electric Currents.—The first studies in ionization, then called cataphoresis because the cations of metals were alone employed (the word cataphoresis being now mainly restricted to the flow of water physically propelled from the anode to the cathode), was made in the early 90's by Georges Gautier, of France, and later by William James Morton and Margaret A. Cleaves, of America, followed in 1895 by the writer's first publication on massive surgical ionization of malignant growths.[1] Comprehensive and clear views of the subject date from the admirable papers and monograph of Leduc, of France, from 1900 to 1903, seconded by H. Lewis Jones, of England, in a valuable monograph issued in 1913. All the early studies, except the writer's, should be understood as referring to the local medicinal or surgical action of ions rather than the general medicinal action, for ions of the heavy metals, usually copper and zinc, were driven in for purely local effects, unless the action of cocaine ions for local anesthesia should be considered as medicinal. The first diffusion of ions for medicinal purposes of a constitutional nature was inspired by Edison about the time of Morton's work, the ions of lithium being diffused into gouty joints with good results.

Three important questions arise in connection with the driving into the body of ions foreign to it:

1. Substances are driven in as simple ions, such as the charged atom of a metal, and also as a molecule ionized, such as the base of the salt cocaine hydrochlorate; the molecule cocaine going in as an actual cocaine cation from the positive pole, while if the same salt were placed in solution under the negative electrode chlorine and hydrogen would be driven in and the cocaine precipitated backward on the negative plate. The same thing is true in the case of sodium salicylate, except that the salicylic ion is an anion and is driven in from the negative pole.

2. The amount driven in depends on the current

strength and the time of application, and may be calculated for the coulomb (an ampere per second) for any substance by multiplying its combining weight by 0.01. This gives the amount driven in by an ampere per second. Dividing the figure thus obtained by 1,000 gives the amount driven by a milliampere per second. Multiplying the last figure by 60 will, of course, give us the practical figure of the amount driven in by each milliampere per minute of application.

3. The depth of penetration of the ions depends on several factors, and is best determined by actual experiment. The factors are: the ionic speed of elements and molecules, which differs with each and is greatest in simple ions of single elements, particularly hydrogen, and least in complex ions, for each atom of the complex ion takes a separate charge and therefore requires more current to be driven to the same depth as single ions; and the fact that metal ions penetrate but little as ions because of their tendency to form insoluble compounds with the phosphoric acid of the plasma and the albumin of the tissue cells.

The Diffusion of Ions for Local Effects.—The bulk of ionization work so far done has been the employment of certain metallic ions for their local antiseptic action, particularly zinc, copper, mercury, and silver ions. Each of these ions is driven in from the anode, and since a peculiarity of their action, as contrasted with that of medicinal substances merely applied to the surface, is that the ionization process *drives the microbicidal ions into the interior of the affected cells* instead of merely on or between them, *reaching and killing endocellular organisms by chemical union with the albumin and salts of which they are composed*, the method is of great value in a variety of local disorders of an infective character, such as chronic ulcers, eczematous patches, ringworm, alopecia, multiple warts, etc.

The method of ionization of broad surface lesions of this character is by placing on the surface to be treated a thick pad of absorbent cotton saturated with a two to five per cent. solution containing the ion to be used (sulphate of zinc will furnish the zinc ion, sulphate of copper the copper ion, and so on, the sulphuric ion going backward to the metal of the electrode, while the metallic ion is driven in); a conducting plate of the metal of the ion or of carbon with fine conducting wire attached is placed over the pad and held in place with strips of adhesive plaster. The wire attached to the plate being connected with the anodic binding post, and with a large dispersing pad beneath a plate connected with the cathode on some distant part of the body, a current of two to four milliamperes per square centimeter of active pad surface is gradually turned on and maintained for five to fifteen minutes according to the severity of the lesion. The application may be repeated at proper intervals until the desired effect is obtained.

The penetration of ions from solutions with these weak currents is not great in the five to fifteen minutes advised, but the method is strikingly effective in all superficial ulcerations depending on infective agencies, and doubtless acts by raising the opsonic resistance of the part as well as by killing intracellular organisms.

In sinuses, whether tuberculous or not, lupus, small skin keratoses, and small skin epitheliomas, trachoma, fistula and fissure in ano, hemorrhoids, boils, carbuncles, and individual warts the best form of application is by insertion of a needle of the metal to be ionized, preferably zinc, directly into the nodule, sometimes with a small drop of cocaine solution at the point of puncture so that cocaine ions will penetrate simultaneously. In the case of sinuses and fistulas the electrode takes the shape of a blunt probe of zinc, and in these cases it will be found desirable to add the effect of the mercury ion by amalgamating the zinc probe with quicksilver. The current strength may vary from one to twenty milliamperes in accordance with the sensitiveness of the patient. A single application of sufficient duration will destroy the small neoplasms mentioned, but sinuses usually require repeated fifteen-minute applications until healed from the bottom.

A valuable ion of recent introduction is the magnesium ion, driven in as a cation from the positive pole from a five per cent. solution of magnesium sulphate. The essential germ of warts seems to be killed by it readily, the warts disappearing in about two weeks. The arsenic ion may be driven in as an anion from the cathode by using a solution of arsenite of potassium, or as a cation in the surgical diffusion of the metal arsenicum in the treatment of inoperable carcinoma.

The Diffusion of Ions for Regional and Constitutional Effects.—The diffusion of medicinal ions for local effects has been considered. In these instances the ions were diffused directly into the cells and fluids of diseased tissues from solutions or electrodes in direct contact with the structures, the ions being made to penetrate to an extent appreciable to the eye or touch of the operator. The dosage of current, area of diffusion, and time of application are thus subject to more or less immediate control from the immediate effects produced.

Possibly of equal value in medicine is the diffusion of ions into a more or less circumscribed region the seat of disease, such as a joint, an inflamed nerve or ovary or other inflamed organ, in each instance the diseased region being overlaid by healthy skin and other structures. Here it is necessary to cause the ions to traverse the skin without undue irritation, hence the pad containing the solution must be as large as the region treated, of considerable and equable thickness, well supplied with the solution, and covered with thin metal as diffusing surface such as tin foil, that will readily conform to the surface in action and remain equidistant from all portions of the skin surface. A fine conducting wire (No. 32) is readily attached to the foil by a bared end being held fast on its outer surface with adhesive plaster, the whole being held in place with a few turns of bandage.

Though it would be better to have this metal plate made of the metal forming the ion, or else some refractory substance such as carbon, platinum, or gold, the tin foil will answer if the absorbent cotton pad is thick enough to absorb the tin and lead ions itself during an application sufficiently strong and long enough to drive the medicinal ions before them into the body. A new pad and solution should be used at the next application as the old one would contain the tin and lead ions of the previous application.

The duration of these regional diffusions should be not less than fifteen to twenty minutes. With a thick pad, and the current may be of many milliamperes, considering the large size of the equally conducting surface of application.

An important physical fact in connection with regional diffusion is the slowness with which the ions reaching the diseased structures are carried further by the lymphatic and vascular circulation, thus giving greater duration to the remedial effect than any other mode of treatment.

The salicylic ion, diffused as an anion by the cathode from a two to five per cent. solution of sodium salicylate has been largely employed in Europe in gout, rheumatic conditions, perineuritis, and neuralgia, and locally in the treatment of pruritus. In trigeminal neuralgia quinine ions have been diffused as cations with marked benefit. In the septic joint affections the salicylic ion has been employed in large doses with marked benefit after the source of the infection has been removed. Prolonged application with large electrodes is necessary. Lewis Jones prefers this ion to other treatment in facial paralysis.

Students of ionization under the leadership of Leduc are much impressed with the sclerolytic effect

of chlorine anions, which are necessarily diffused when a sodium chloride solution is placed under the cathode. In such an application chlorine ions and the hydroxyl ions accompanying them seem to cause an absorption of redundant scar tissue, an effect which Desfosses and Martinet attribute in part to the decalcifying action occurring at the negative pole. The combined effects have been made use of to soften scars, ankylosed joints, Dupuytren's contractions, to reduce keloid-like redundancies, remove corneal opacities, etc.

Iodine ions, diffused as anions from solutions of the iodides, are somewhat irritating to the skin, but have been used in goiter, and particularly in the various forms of fibrositis, in the latter replacing chlorine.

Major Ionic Surgery.—The employment of zinc ions, or zinc and mercury ions, with current sufficiently strong to cause the immediate surgical destruction of malignant growths was original with the writer of this article, the first effort having been made in 1893 with monograph publication in 1910.[2] The purpose of the method is the application of the principles enunciated in preceding paragraphs on a scale of sufficient magnitude to infiltrate all the cells of a still local carcinoma or sarcoma with ions of zinc and mercury, or of zinc alone, up to and just beyond their actual peripheries. Under general anesthesia or efficient local anesthesia this may be done in the largest neoplasms in from twenty to forty minutes with an adequate current strength. The latter varies from 100 to 2,500 milliamperes according to the size of the growth. The whitened, sterile slough thus produced separates spontaneously in from seven to twenty-one days, leaving a healthy wound to cicatrize under emollient dressings of dilute zinc oxide ointment.

The chief risk to the life of the patient in the more serious growths destroyed in this manner is due to the possibility of secondary hemorrhage on separation of the slough when the growth is supplied with large vessels. In the small percentage of cases in which this occurs the hemorrhage may be controlled by compresses saturated with carbolized Monsell's solution of the perchloride of iron, the compresses being left in place until closure of the vessel has occurred.

The principal advantage of this procedure over the ordinary operations of excision and amputation are: its bloodlessness; the fact that all germs specific to the neoplasm are killed *in situ* and cannot therefore be reimplanted by accident in the edges of the wound as may occur in the ordinary operation; that all edges are sealed, thus cutting off inward migration of diseased cells and lessening pain, by reason of sealed nerve fibers; that it permits growths to be attacked successfully through themselves outward, reaching the peripheries from within the growth, thus conserving overlying and contiguous structures and lessening unnecessary mutilation; and that growths within cavities may be thus destroyed by a force carried through small natural openings by means of insulated electrodes.

An advantage of the method, as compared with effective radium and Röntgen ray destructions of cancer, is that the slough produced is practically outside the body of the patient, being walled off by sealed absorbents, hence the sloughing period is unattended by dangerous absorption of débris.

As developed during the twenty-one years of the writer's employment of the method it may be divided into two procedures, the unipolar and the bipolar methods, the latter being the more recent and efficient technique when it can be employed.

The Unipolar Operation.—This method is an amplification of the minor application with active anodic electrodes of zinc needles, or zinc needles amalgamated with mercury, inserted in the peripheries of the growth in such manner that the ions will infiltrate the whole of it and extend a little beyond, the cathodic pad being beneath the patient's back and increased to as large a size as possible. Pads of kaolin clay covered with linen and thoroughly moistened with warm water are best for the latter purpose. Under general or efficient local anesthesia the electrodes are inserted and a current of 300 to 500 milliamperes is turned on without shock and maintained until the ions produced by the ionization of the zinc needles have thoroughly infiltrated and whitened the growth.

This unipolar technique has the disadvantage of producing a tetanizing effect on underlying nervous and muscular structures, and is therefore contraindicated in such situations as the mammary gland, the neck, and the head.

The Bipolar Operation.—In this operation, which is now the operation of choice whenever the growth presents sufficient bulk to separate the poles properly, the zinc electrodes are inserted as in the unipolar operation, but the negative pad is replaced by an electrode attached to this pole that is placed on or inserted within the center of the growth. As the circuit is purely local to the part no limit need be placed on the strength of the current, and large growths may be infiltrated with the ions and turned white, sterile, and soft to the touch in from thirty to forty minutes, a sufficient number of active electrodes being employed to include the whole periphery in the effect without delay.

Of 300 malignant growths treated by these methods by the writer between July 31, 1893 and December 31, 1913, 129 remain apparently cured after periods varying from seventeen years to one year, or 43 per cent. The total mortality of the ionic operations performed was eleven, or 3 6 per cent.

The percentage of operable cases cured was 93.5. and that of inoperable cases (or those in which excision had failed, or was impossible) 20.2 per cent

G. Betton Massey.

References.

1. Medical News, March 9, 1895.
2. Ionic Surgery in the Treatment of Cancer, A. C. Chatterton Co., New York, 1910.

Ions.—The organic salts are spoken of as electrolytes, that is they are conductors of electrical currents. If copper suphate is dissolved in water in a platinum dish and an electric current is passed through the solution, using the platinum dish as the negative electrode and inserting the positive electrode in the solution, it will soon be evident that there is no longer a blue solution of copper in the dish. On the other hand inspection will show that there is a thin red layer of copper on the dish. Reversing the current causes the copper to leave the dish and deposit upon the electrode inserted in the water. This experiment shows the ability of the copper to travel from one electrode to the other and it is by this wandering that the electricity is carried. The copper sulphate is dissociated into two parts—two *ions*—copper carrying a positive charge which goes to the negative pole or cathode, hence called the cation, and SO_4 carrying a negative charge wanders to the anode and is hence designated as the anion. When a substance such as sodium chloride is dissolved in water the same process takes place to a certain extent—the more dilute the solution, the greater the dissociation. It is only in an ionized state that chemical reacting can occur. The acids owe their character to the hydrogen ion, alkalies owe theirs to the OH ion.

F. P. Underhill.

Ipecacuanha.—Ipecac. The dried root of *Cephaëlis Ipecacuanha* (Brot.), A. Richard. [*Uragoga Ipecacuanha* (Brotero) Baillon (Rio Ipecac), or of *C. acuminata Karsten* Carthagena Ipecac) fam. *Rubiaceæ*)], yielding, when assayed by the U. S. P. process, not less than 1.75 per cent. of ipecac alkaloids. The U. S. P. now permits the presence, attached to

the root, of a portion of the stem base not exceeding 7.5 centimeters in length. It has been proposed to change this by allowing ten per cent. of stem to be present. It is also proposed to increase the requirement of alkaloid to two per cent. The name of this drug, which is adopted into most European languages, is borrowed from the South American Indians, by whom it is used to designate, not only this, but several other emetic roots. *Poaya* is another Bazilian name, also rather loosely applied to other roots besides the one under consideration. "Ipecac" is a natural and convenient abbreviation.

The plants from which this drug is obtained are low, semi-gregarious shrubs, growing in the deep tropical woods of Brazil, with partly creeping stems and thickened annulated roots.

The roots, several in number, are long, tortuous, simple or slightly branching, white and filiform when young, but at maturity thickened to three or four times the diameter of their woody columns by the accumulation of starch-bearing tissue in the bark. This thickening occurs in crowded, narrow, irregular, and generally incomplete, transverse rings, separated by deep, also incomplete, circular constrictions, and is greatest in the middle portion of the root, which tapers toward each end, especially the lower. The woody column does not take part in either the rings or furrows of the bark. The stems of *Cephaëlis* are of soft woody, sometimes almost herbaceous, texture; rounded, smooth, creeping, and rooting below; ascending, square, pubescent, and green above, with well-marked nodes and leaf scars. It is this lower, rounded portion, lying shaded and for the most part covered by forest débris, which has practically the same composition and properties as the root, and which might be, and commonly is, used with it. The upper portions of the stem are very deficient in alkaloid and should not be included. The remaining portions of the plant are well illustrated in the accompanying cut, which, however, does not show the prostrate habit of the basal portion of the stem.

Habitat.—The district of Matto Grosso, in western Brazil, is the principal source of Rio ipecac; but the plant grows also in the adjoining parts of that country as well as of Bolivia. The ipecac plant has been long cultivated as an object of interest in botanical gardens, especially in that at Edinburgh. Mr. McNab made the important discovery that it could be propagated by minute fragments of its roots, or even of its leaf stalks. By means of this plan a large number of plants has been obtained and sent to India and elsewhere for experiments in regard to its practical cultivation; so far, however, because of the slowness of its growth and the smallness and consequent expensiveness of the yield, its culture has not been commercially successful, and we are still obliged to rely upon its native country for our supply. It is collected by the Indians in Brazil throughout the year, but mostly during the wet season, when the ground is soft, by simply grasping the stems in one hand and prying out the roots with a pointed stick held in the other. The gravel is then shaken out and the roots are dried in the air. When dry, they are sifted and sorted and packed in serons (bales made of hide) for transportation. It is mostly bought up by traveling traders, and suffers much exposure during their journeys, so that much of it reaches us in a mouldy and damaged condition. Ten or twelve pounds per day is said to be a good average collection. Ipecac collection is exceedingly irritating to the hands, especially the finger ends, as well as to other parts of the body, and is hence very objectionable to the laborers. The modern high price for rubber having afforded a profitable opening, its collection is preferred, and the price of ipecac has on this account very greatly advanced. Very little is known about the occurrence of the Carthagena variety.

History.—The following paragraph is condensed from Flückiger and Hanbury. A doubtful reference to ipecac is made in an old treatise upon Brazil, published by Purchas in 1625. Piso and Marcgraf (1648) described it, and stated that it was in common use in Brazil. It was first carried to Europe in 1672, and its usefulness established by Helvetius about 1686, who kept its identity a profound secret until he received from Louis XIV. a handsome price for publishing it to the world in 1688. This early use of ipecac was not as an emetic, but in the treatment of dysentery, which is still its principal employment in tropical countries.

Official Description.—In pieces of indefinite length, rarely exceeding fifteen centimeters (six inches), and three to six millimeters (one-eighth to one-fourth inch) thick, curved and sharply tortuous, almost free from rootlets; surface red-brown or brown, occasionally blackish-brown, rarely gray-brown, closely annulated and usually exhibiting transverse fissures through the back, their sides vertical; fracture short, the very thick, easily separable bark grayish, usually resinous, the thin wood yellowish-white, without vessels; odor very slight, peculiar; taste bitter and nauseous, somewhat acrid.

When very thick, of a dull gray color, with thin, merging annulate and with many starch grains exceeding 12 or 14 μ it is from *Cephaëlis acuminata* Karst.

When ipecac is sound and free from mouldiness, its quality is proportionate to the thickness of the bark and the thinness of the ligneous portion.

The bark of ipecac consists entirely of thin-walled, polyhedral cells scarcely longer than broad, and pretty well filled with clustered and faceted starch grains, solitary grains rarely reaching a diameter of 12 or 14 μ. Liber wanting. All the medicinal activity of the drug resides in the bark, the wood being worthless and nearly tasteless.

Adulterants and Substitutes.—The adulterants of and substitutes for ipecac have been so numerous and important that works have been written upon the subject.

Composition.—The medicinally unimportant constituents of ipecac are a large amount of starch and calcium oxalate, and small amounts of pectin, sugar, and resin. The important constituents are *ipecacuanhic acid* and the alkaloids, namely, *cephaëline*, *emetine*, and a third not yet studied, the three alkaloids together existing to the extent of about two per cent. Of this total, the emetine constitutes about three-fourths, the cephaëline about one-fourth, in Rio Ipecac, this ratio being often reversed in the Carthagenic variety, which contains a larger total of alkaloid, the third being in very small amount. The physiological and therapeutical importance of the ipecacuanhic acid and of the third alkaloid is not known, but there are special reasons why it is in great need of investigation, especially that of the former substance. There is nothing in the action of either emetine or cephaëline to explain the repute of ipecac in the treatment of dysentery, a repute so strong and general as to demand recognition. This effect appears to be secured, moreover, after the removal of the alkaloids, and it would appear that it must be due to the bitter acid, which is in reality a glucoside.

Cephaëline ($C_{14}H_{19}NO_2$) is separated from *Emetine* ($C_{14}H_{18}(CH_3)NO_2$) by the use of an aqueous solution of caustic alkali, the emetine being taken up from it by ether.

Action.—Ipecac (and still more the alkaloid) is a moderate local irritant, producing smarting, redness, and, if a long-continued application is made to the skin, finally troublesome pustulation. The powder of either, inhaled, produces sneezing, stinging, and increased secretion from the nostrils and deeper air

passages; in susceptible persons a severe coryza may be simulated. In experiments upon animals, diarrhea, with bloody discharges and inflamed intestinal mucous membranes, has followed large doses. It is thus evident that local stimulation, or irritation at least, forms a very characteristic part of the action of ipecac. This is also seen in the pain and inflammation, frequently abscess, at the point of hypodermic injection, on account of which this mode of use is not available. As to the systemic effects when thus introduced into the circulation, it is to be noted that in fatal cases severe inflammation of the lining of the stomach and intestine has frequently been observed, all the indications being that it has resulted from excretion of the alkaloids into these organs. Irritation of the pulmonary tissue, which is often severe, is apparently due to a similar excretion there. The emetic action of the drug, as well as the salivation and nasal discharge, could thus be readily explained on the ground of local irritation. When the alkaloid is taken, it is distinctly noted that there are two periods of gastric disturbance, one following the other at an interval of about thirty minutes. It has been thought that this second attack was due to central action, after the alkaloid had become absorbed; but it is at least possible that it follows its re-entrance into the stomach upon excretion from the circulation. Whether the emesis of ipecac is purely a local effect or partly of central origin, is the most important question concerning it. It is notable that the disturbance of emetine is less than that of cephaëline, of which latter emetine is a methyl compound; and we know that methyl compounds are often less energetic irritants, or are even sedatives, to the centers. This would seem to indicate central activity. This question is not of practical importance, as the general effects of the drug are clear and evident. When taken into the stomach, there is salivation and perhaps coryza, followed by nausea, and accompanied by some diuresis and considerable diaphoresis. If free vomiting occurs, these effects will quickly pass away; but if not, they will be prolonged, and with one or more exacerbations. In the latter case, too, there is more apt to be a laxative or even a purging effect, as is also the case after hypodermic injections. The respiratory mucous membrane generally shares in the increased secretion. Ipecac is therefore a nauseating expectorant and an emetic, with a cathartic tendency. Its emetic action is characterized by its slowness. If cephaëline is given, the nausea and salivation are more marked; if emetine, the nasal secretion is more in evidence. Very large doses are poisonous, the symptoms being those of emetico-cathartic irritants, but with great depression, which appears almost certainly due in part to central action. A cholagogue action is distinct. This cannot be explained on the theory of mechanical pressure upon the gall bladder from the retching, because it will occur when this is not present.

Use.—The expectorant and emetic uses of ipecac follow clearly from its action as above described, but not its antidysenteric. As an emetic it is not suitable for use in poisoning, as it is not prompt enough, and is too apt to be irritating. This action is, however, often of great value when we wish to carry its relaxing effect to the extreme, as in acute bronchitis. Very small doses of ipecac will often exert an anti-emetic action, and will also promote appetite and digestion. The chief use of the drug is, however, as an expectorant, in which it both increases the secretion and stimulates its removal, yet acts as a sedative or anodyne when there is annoying cough without much secretion. This action is quite prolonged, and the effect is easily maintained by repeated small doses. The diaphoretic action is an important accompanying factor. As an antidysenteric, ipecac is better adapted to the stomachs of savages than to those of most civilized persons, for the doses are so large (a dram or more) that the treatment is heroic. De-emetinized ipecac is for this reason preferred, but it has been claimed that it lacks efficiency. The mode of action is not known. It is not impossible that in the true dysentery of the tropics, in which cases it is far the more efficient, it acts as a specific rectal antiseptic, as it is known to have antiseptic powers.

The preparations are numerous. The drug is very largely employed in the powdered form. As an expectorant, the dose is gr. ss. to i. (0.03–0.06), as an emetic gr. xv. to xxx. (1.0–2.0), as an antidysenteric gr. lx. to xc. (4.0–6.0), or a full emetic dose followed by fifteen-grain (gram) doses. The official fluid extract is given in corresponding doses of cubic centimeters or minims. The seven and one-half-per-cent. syrup and the ten-per-cent. wine are to be adjusted, in proportion to their strength, for the same requirements. The tincture of ipecac and opium, containing ten per cent. of each, is used when a specially sedative expectorant effect is desired, but not when we specially desire the clearing of the air passages. In the preparation of the last three the fluid extract of ipecac is employed. The same statement concerning selection applies to the powder of ipecac and opium (Dover's powder), having the same strength. The official troches contain, each, gr. $\frac{1}{8}$ of ipecac, and the troches of morphine and ipecac, each gr. $\frac{1}{40}$ of morphine and gr. $\frac{3}{40}$ of ipecac.

The rectal injection of ipecac for the treatment of chronic constipation has been tried, and it would seem that further experiments in such use are desirable.

Henry H. Rusby.

Ipecac, North American.—False Ipecac, Indian Physic, Bowman's Root.—The roots of *Porteranthus trifoliatus* (L.) Britton, (*Gillenia trifoliata* Moench), and *P. stipulatus* (Muhl.) Britton, (*G. stipulacea*, Nutt.) (fam. *Rosaceæ*). These are pretty perennial herbs, with clustered, erect, or ascending stems, resembling the Geums, deeply three-parted leaves and white flowers. The former grows west to Missouri and south to Georgia; the second somewhat farther south and southwest. The roots grow from a hard, woody, and knotty crown about an inch in diameter. They are numerous, much and very crookedly twisted, knotty, and interlacing, especially the second species. The roots are annulate and transversely fissured and of a deep reddish color, thus giving them an appearance very similar to that of ipecac, which they have been used to substitute and adulterate. The bark is brittle, like that of ipecac, but the wood is thicker and much tougher, and has conspicuous slender medullary rays, which extend slightly into the bark. Strangely enough, the drug possesses properties similar to those of ipecac. It was highly prized by the aborigines as a mild emetic and nauseating expectorant, purgative also in larger doses, and was much used by the settlers. It is still employed to a considerable extent, and somewhat by physicians. The emetic property appears to reside in the peculiar neutral substance gillenin, which is extracted as a white powder, soluble in water and alcohol. It is probably a glucosidal mixture. "Gillenin" of commerce is a resinous extract, containing the other, and is given in doses of gr. iv. to vi. (0.25–0.4). The dose of gillenia is gr. xv. to xxx. (1.0–2.0).

Henry H. Rusby.

Iris.—Blue Flag. The rhizome and roots of *Iris versicolor* L. (fam. *Iridaceæ*). This is a very common swamp plant of eastern North America, erect, about two or three feet high, with sword-shaped, equitant leaves and handsome blue flowers, marked in the center with white and yellow stripes.

Rhizome of horizontal growth, branched, the branches five to ten centimeters (two to four inches)

long and one to two centimeters (two-fifth to four-fifth inches) thick, cylindrical in the lower half, thence becoming vertically flattened toward the crown, where it is terminated by a circular scar; dark brown, wrinkled, annulate with the leaf bases; fracture short, purplish; roots long, slender, simple, crowded near the flattened end; odor peculiar; taste pungent, acrid, and nauseous.

This drug was in use by the aborigines, and has been employed to a moderate extent by physicians for many years. The uncertainty and harshness of its action have, however, prevented its becoming a favorite. An acrid resin, fixed oil, tannin, gum, starch, etc., are given as its constituents.

It belongs to the resinous class of cathartics. When quite fresh, it is an irritant emetico-cathartic, easily acting as a poison in overdoses. Upon drying and keeping, these harsh actions are continuously ameliorated, and after a year or more it becomes a reliable purgative, not excessively harsh if given properly diluted and with the drug well distributed through the excipient. It then ranks with jalap, leptandra, and similar drugs.

Dose of the powder, from gr. viii. to gr. xxiv. (0.5–1.5). An extract (*Extractum Iridis*), dose gr. i. to iij., and a fluid extract (*Extractum Iridis Fluidum*), dose ♏ x. to xxx., were official when this drug was recognized in the U. S. P. A precipitated extract, "Irisin" or "Iridin," is in rather common use.

HENRY H. RUSBY.

Iris, Diseases of the.—The iris is a specialized part of the uveal tract, which includes also the ciliary body and choroid. A disease process affecting any one of these three intimately related structures is extremely likely to involve the rest of the tract in greater or lesser degree. The parts of the eye directly concerned in the process of vision are the recipient element, the retina, and the transparent media—the cornea, aqueous humor, lens, and vitreous—through which the light is transmitted to its destination. Whatever destroys the integrity of the uveal tract is likely to affect the nutrition of the retina or of ths transparent media; and any inflammation of the uveal tract, including inflammation of the iris, ie likely to interfere with the transparency of either cornea, lens or vitreous, or of all three.

The anatomic continuity of the iris with the ciliary body, and of this with the choroid, recalls the fact that all three have in the main the same embryonic origin, viz., from the encircling mesoblast. They form the vascular and nutritive tunic of the eye. Just as the choroid is lined within by the pars optica retinæ, so the same epiblastic layer of the primitive eye is continued on to the ciliary body as the pars ciliaris retinæ, and on to the iris as the epithelium which forms its posterior layer. The remainder of the iris is mesoblastic in character.

From before backward the iris consists of the following layers: (1) the anterior stroma layer, (2) the vascular layer, (3) the smooth muscle layer, including the dilatator and sphincter pupillæ, and (4) the pigment epithelium of the iris. The anterior stroma layer is poor in fibers and rich in protoplasm. The principal elements of the vascular layer are the two anastomosing circles, known as the circulus arteriosus major and circulus arteriosus minor, the one lying toward the periphery of the iris, and the other near its pupillary border. The blood supply of the iris is derived from the long posterior and the anterior ciliary arteries. The fibers of the dilatator muscle are sparsely scattered near the pigment layer. The sphincter pupillæ is a denser mass of muscular tissue lying close to the pupillary margin.

The surface of the normal iris presents a number of irregularities, due to unequal massing of the minute blood-vessels. The depressions thus formed are spoken of as crypts, and after severe or long-continued inflammation, or after prolonged increase of intraocular tension, tend to become blurred and to lose their characteristic sharpness. The root of the iris is in close relationship with the ciliary muscle, the angle of the anterior chamber, the ligamentum pectinatum, the canal of Schlemm, and the sclerocorneal junction (see Fig. 3538). At the pupillary margin the iris lies normally in contact with the anterior capsule of the crystalline lens. The nerve supply of the iris is derived from the ciliary branches of the lenticular ganglion, and from the long ciliary nerves from the nasal branch of the ophthalmic division of the fifth nerve.

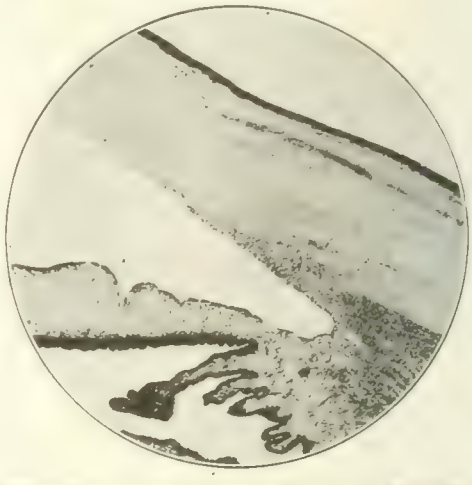


FIG. 3538.—Normal Angle of Anterior Chamber. (From Parsons.)

THE AQUEOUS HUMOR.—The iris separates the aqueous humor of the posterior from that of the anterior chamber. There is reason to believe that the intraocular fluid, especially the aqueous humor, is renewed by secretion from the epithelium on the posterior surface of the ciliary body, and in less degree of the iris. The aqueous humor is removed from the eye almost entirely through the peculiar system of drainage channels at the angle of the anterior chamber. This system is composed of the spaces of Fontana in the ligamentum pectinatum, of the specialized venous channel known as the canal of Schlemm, which consists merely of a space lined with endothelium, and of a group of veins with which this canal is in close relationship. The ligamentum pectinatum is covered with endothelium, continuous with that which extends over the posterior surface of the cornea.

The secretion of the aqueous normally balances its excretion from the eye, the amount produced being probably regulated by the relation between the tension in the intraocular capillary vessels and that existing within the eye itself. The aqueous humor ordinarily contains only a trace of albumin, together with about one per cent. of salts (chiefly sodium chloride) and organic substances. The so-called "secondary aqueous" which rapidly collects after any form of traumatism by which the primary aqueous is allowed to escape from the anterior chamber, is much richer in albumin, and also contains various protective bodies which are absent from the normal aqueous. The same is true of the aqueous which is secreted in inflammatory conditions involving the uveal tract or cornea; and during such inflammations the aqueous also frequently contains a considerable number of leucocytes. The composition of the aqueous humor is also altered in case of hemorrhage into the anterior chamber from the iris or ciliary body, or in the event of extensive hemorrhage from the posterior structures of the eye. In some inflammatory conditions a mass of fibrin, in

which are enmeshed white blood corpuscles, accumulates at the bottom of the anterior chamber. This mass is commonly spoken of as hypopyon, although it usually contains no bacteria, and is seldom of fluid consistency.

The depth of the anterior chamber is pathologically reduced in some cases of glaucoma, in the presence of rapid swelling of the lens, and in cases of adhesion of the iris to the cornea. (See Fig. 3539.) It is increased when the lens is absent or displaced, and in anterior staphyloma.

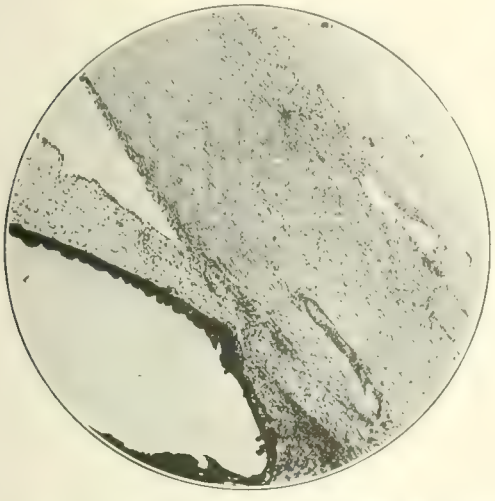


Fig. 3539.—Peripheral Anterior Synechia. Secondary glaucoma from detached retina following a blow. (From Parsons.)

Color of the Iris.—The color of the iris determines whether the individual is spoken of as having blue, gray, green, or brown eyes as the case may be. The color at birth is almost invariably blue. This depends upon the fact that at birth the stroma of the iris contains little or no pigment, but gradually becomes pigmented to a greater or lesser extent during childhood and adolescence. The color of the blue or gray eye depends upon the pigment epithelium of the iris, and the dark brown eye is one whose iris stroma contains a great deal of pigment. The intermediate shades represent varying degrees of pigmentation of the stroma, the color of the stroma being blended with the blue tint which arises from the pigment epithelium. The pigment deposits in the stroma often present marked irregularity, even in the same eye. Cases of inequality as between the two eyes, one eye being blue and the other brown, are not infrequent. The condition is known as *heterochromia* iridis, and usually occurs in the child of parents one of whom had blue and the other brown eyes. The color of the iris becomes more or less green in iritis, and a rusty brown in some cases of long-continued residence of a fragment of iron within the eye. In some cases of heterochromia the blue eye seems especially liable to the development of cataract.

Congenital Defects and Anomalies of the Iris.—Anomalies of color of the iris, including heterochromia, have just been mentioned. Absence of the iris, *aniridia*, although apparently complete, is never absolutely so, a rudimentary stump of iris being always present, although hidden from view behind the opaque sclera at the angle of the anterior chamber. These eyes are very liable to glaucoma, possibly by reason of adhesion of the stump to the periphery of the cornea, with obstruction to the outflow of aqueous. The condition is usually bilateral, and is commonly accompanied by nystagmus, and also frequently by anterior and posterior polar or lamellar cataract. *Congenital coloboma* of the iris is usually associated with a defect in the suspensory ligament of the lens, a corresponding coloboma of the lens margin, and a coloboma of the choroid; these defects all appearing at the lower, or lower-inner aspect of the eyeball, and being probably due to failure of normal closure of the secondary optic vesicle at the site of intrusion of the invaginating mesoblast. As regards the iris the coloboma may vary from a mere notch to a defect extending to the root of the iris (see Fig. 3540). The pupil is thus rendered pear-shaped. The pillars of the coloboma are sometimes bridged by a strand of iris stroma (see Fig. 3541). According to Kruckmann traces of the sphincter

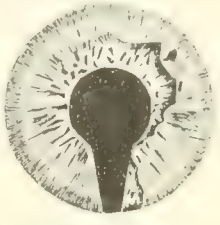


Fig. 3540.—Coloboma of the Iris. (After Segal.)

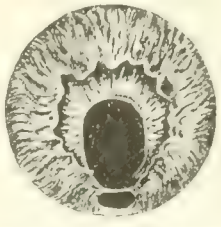


Fig. 3541.—Bridged Coloboma. (After Sachsalber.)

muscle are always to be found all the way along the margin of the coloboma. *Polycoria.* No instance has been recorded in which more than one pupillary opening was surrounded by a sphincter muscle. But in rare cases there exist, in addition to the normal pupillary opening, accessory gaps in the iris tissue, commonly located close to the pupillary border, but separated by it from the true pupil.

Persistent Pupillary Membrane.—During a large part of fetal life the anterior surface of the lens is covered by a nutrient layer of vascular mesoblastic tissue, the anterior fibrovascular sheath of the lens, from which the stroma of the iris is in part differentiated. This membrane normally disappears before birth, but in a considerable percentage of normal eyes some trace of it persists throughout life. Such remains take a great variety of forms, from mere dots of pigmented tissue on the anterior surface of the lens to a complicated network lying across the pupil (see Fig. 3542). Almost invariably such remains as are attached to the iris arise from the lesser arterial circle, and this feature is of importance in diagnosing persistent pupillary membrane from acquired adhesions. The threads or bands of tissue have the same color and general structure as the stroma of the iris. It is rare to find the vision impaired by the presence of a persistent pupillary membrane, and treatment is unnecessary. In a few instances adhesion of the membrane to the cornea has been reported.

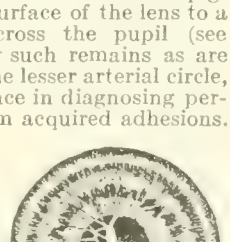


Fig. 3542.—Persistent Pupillary Membranes. (After von Hippel.)

Congenital Ectropium Uveæ.—The posterior layer, or pigment epithelium, does not in man normally extend on to the anterior surface of the iris, although such an extension is present in horses in the form of the so-called "corpus nigrum" at the upper margin of the pupil. Slight extension on to the anterior surface may, however, be seen exceptionally in the human subject. This is known as congenital uveal ectropion, and is to be distinguished from acquired ectropion, which is sometimes seen in atrophic conditions of the iris following inflammation or glaucoma.

The Pupil.—*Function of the Iris.*—The function of the iris is essentially to regulate the amount of light which reaches the retina, although incidentally it also serves

to diminish the amount of spherical aberration due to the passage of rays of light through the periphery of the lens. In the albino eye the protection afforded by the iris is almost nil, hence the extreme sensitiveness of these eyes to bright light. When the normally pigmented eye is exposed to strong light the retinal stimulation results in excitation of a reflex arc whose objective is contraction of the pupillary sphincter, with simultaneous relaxation of the dilatator pupillæ. When the light entering the eye is of feeble quality, the sphincter muscle relaxes and the dilatator muscle is stimulated to contraction. The sphincter is controlled by the third or motor oculi nerve, and the dilatator by fibers from the superior portion of the cervical sympathetic. Contraction of both pupils normally follows promptly upon stimulation of either retina.

Appearance of the Pupil in Youth and Age.—The often noted bright eye of youth and the "dull eye" of age have a physical explanation. The color of the pupil depends upon the relative transparency of the crystalline lens. The lens is never absolutely transparent; that is to say some rays of light falling upon it are reflected instead of passing through to the ocular fundus. These reflected rays may be studied by illuminating the dilated pupil very obliquely from one side, and observing it at a similar angle from the other side. A faint gravish reflex from the anterior surface of the lens will be seen. In later years this reflection is very much more noticeable, being often quite pronounced without dilatation of the pupil and without any care as to the use of oblique illumination. In fact it is often so striking as to be mistaken by careless observers for cataract, although the patient's vision may be perfectly normal and the surgeon may experience no difficulty in seeing the details of the fundus.

Mydriasis and Miosis.—Since the range of dilatation and contraction of the pupil depends largely upon the elasticity of the iris stroma, which consists largely of a network of blood-vessels, the pupil of old age, with its thicker and more rigid blood-vessel walls, is usually not merely narrower, but also less variable in size, than that of early life. In inflammatory conditions of the iris, and also to a lesser extent of the cornea, the pupil is usually reduced in diameter; an important point in diagnosing these conditions from glaucoma, in which the pupil is almost always dilated. Certain drugs have the power of dilating the pupil, probably by at the same time paralyzing the nerve endings which control the sphincter iridis muscle, and stimulating those which produce contraction of the dilatator iridis. These drugs are atropine (generally used in from $\frac{1}{2}$ to 2 per cent. solution), scopolamine ($\frac{1}{10}$ to $\frac{3}{10}$ per cent. solution), and homatropine ($\frac{1}{2}$ to 3 per cent. solution). The duration of the influence of these drugs is greatest in the case of atropine (ten to fourteen days in the healthy eye), less in that of scopolamine (about five days) and least for homatropine (two days). All three also paralyze the accommodation, through the ciliary muscle, for similar lengths of time. Cocaine has also a fairly marked mydriatic action, and to a lesser degree produces a weakening of accommodation. For diagnostic purposes, mydriasis may be produced by euphthalmin, a weak solution of homatropine, or cocaine. The two drugs commonly applied as miotics, that is to contract the pupil, are eserine (used in from $\frac{1}{8}$ to 1 per cent. strength) and pilocarpine ($\frac{1}{2}$ to 2 per cent.). The action of eserine is decidedly more persistent and more reliable than that of pilocarpine, although where adequate the latter is to be preferred on account of being less distressing to the patient.

Anomalies of the Pupil.—Most of the anomalies of the pupil have been mentioned above under congenital anomalies of the iris. *Anisocoria* is an inequality of the pupils, and may be congenital or may be secondary to disease in the eye or in the optic tracts and centers, or to traumatism (affecting the pupil which is relatively dilated). Various anomalies of relationship as between the dilatation and contraction of the pupil, the movements of the eyeball, and the elevation of the upper lid, have been reported, but their foundations are not well established. Some of them probably depend on congenital anomalies of interassociation of the cerebral nuclei.

Corectopia is displacement of the pupil from its normal position, usually associated with subluxation of the lens. The normal position of the pupil is not usually quite concentric with the cornea, but falls very slightly to the nasal side.

Significance of Abnormal Pupillary Reactions.—The normal pupil contracts to light and with accommodation and convergence. (It should always be remembered that the contraction to light is very much more pronounced when the light falls upon the macular region than when the periphery of the retina is chiefly affected.) In paretic dementia and tabes dorsalis the pupil reacts to accommodation but not to light (Argyll-Robertson pupil). The contraction of one pupil upon directing the light through the other pupil is known as the consensual light reaction. It is sometimes present when the eye illuminated is blind, but this can only occur when the lesion causing blindness lies behind or central to the corpora quadrigemina. In cases of complete blindness due to lesions between the corpora quadrigemina and the eye, or in the eye itself, the consensual light reflex of the other eye is always lost. The course taken by the visual impulse is from the retina through the corpora quadrigemina to the visual centers in the occipital lobes. Because of the fact that one-half of each optic tract goes to the retina of the right eye, and the other half to the retina of the left eye (the decussation occurring in the optic chiasm), a complete unilateral lesion behind the optic chiasm causes hemianopsia, or blindness of the same side of each retina. If in such case the pupil reacts to light thrown upon any part of the retina, the lesion must lie posterior to the corpora quadrigemina. If on the other hand the lesion is between the corpora quadrigemina and the chiasm, the pupil will react freely to light thrown on the seeing half, but not to light falling only upon the blind half of the retina. But for this test to be reliable, the light in the second instance should be very carefully excluded from the seeing half of the retina.

A pupil which is suddenly exposed to strong light frequently shows several slight oscillations in size after the first strong contraction. When this oscillation is abnormally pronounced in amplitude the condition is spoken of as *hippus*. Persistent contraction of the pupil may be due to the use of a miotic, or to adhesions of the iris to the lens capsule. Failure to contract may be due to use of a mydriatic, to glaucoma, to adhesions, to loss of function of the retina or optic tracts, or to lesion of the motor path from the pupillary center to the iris. The pupil sometimes remains permanently dilated after contusion of the eyeball, perhaps as the result of injury to the nerve filaments supplying the sphincter muscle. Temporary paralysis of accommodation and of the pupillary sphincter sometimes occurs after diphtheria. Sluggish pupillary reactions to light, or inequality of the pupils, may be due to syphilis or other destructive processes involving the central nervous system. Ophthalmoplegia interna is a paralysis of accommodation and of the pupillary sphincter, due to a lesion of the nucleus of the third nerve. Pupillary contraction and accommodation may also be involved with the extrinsic ocular muscles in paralysis arising from lesions of the motor oculi.

The light reaction of each eye separately is best tested by directing the patient to look toward a fairly strong light source, covering both eyes with the

surgeon's hands, and then after a few seconds uncovering the eye which is to be examined. To test the reaction to accommodation and convergence, the patient should look alternately at a distant object and at a pencil or other small object held within a few inches of his eyes. Besides the reactions to light and accommodation, the following may be mentioned: The pupils dilate under the influence of strong emotion, but contract under the influence of pain, such as that produced by pinching the skin. Haab has described a "cerebral cortex reflex" of the pupil. This is produced by illuminating the eye obliquely from a single source in a room which is otherwise dark, requiring the patient to look directly ahead into the darkness, but without any effort of attention, and then requesting him to fix his attention on the light but without looking toward it. When this is done the pupil contracts.

Iridodonesis is a tremulousness of the iris, either general or local, due to withdrawal of the support normally afforded by the crystalline lens. The whole iris is affected in aphakia, as after cataract extraction, and a part only of the iris in cases of subluxation of the lens, the tremor being noticeable on the side opposite to the direction in which the lens is dislocated.

Injuries to the Iris.—*From Contusion of the Eyeball.*—Injuries of the iris from contusion of the eyeball are fairly frequent. *Rupture of the pupillary border* may appear as a minute notching which is only visible when the pupil is dilated, or in rare instances may extend almost to the ciliary border of the iris. The sphincter is sometimes torn at several points. Unless the tear is very minute there is hemorrhage into the anterior chamber. *Iridodialysis* is a separation of the root of the iris from the ciliary body, or at least a tangential rupture of the iris near its junction with the ciliary body. If minute, the hemorrhage which results may fill the gap, and becoming organized bridge over the defect in the iris. But true reformation of the iris tissue does not occur. An iridodialysis is manifested by the appearance at the periphery of the iris of a dark line, which by transmitted light (with the ophthalmoscope or by transillumination) may have the same red appearance as the pupil. At the same time the pupil becomes flattened on the side toward the dialysis. The passage of light through a large iridodialysis may prove a permanent source of annoyance to the patient. *Traumatic mydriasis*, or more or less persistent dilatation of the pupil following contusion, has been mentioned under Mydriasis.

Wounds of the Iris with Penetrating Wounds of the Eyeball.—An aseptic wound of the iris, such as is made in the operation of iridectomy, heals without the formation of granulation tissue along the margins of the cut, the non-irritating quality of the aqueous humor probably protecting the iris from the changes which commonly follow wounds in other parts of the body. In accidental penetrating wounds involving the iris, the injury is seldom confined to that part of the uveal tract, but in most instances extends into the ciliary body. The iris itself is apt to be torn, and to prolapse through the corneal wound, and at times undergoes partial or complete avulsion from its attachment within the eyeball. If the torn iris is found prolapsed through the corneal wound, it is usually proper to excise the prolapsed portion. The eye must, of course, be thoroughly cocainized. Gentle traction (provided the wound is recent) is made upon the iris with forceps, and the hernial tissue cut off flush with the corneal surface. Injuries of this kind are always ollowed by adhesion of the iris to the wound margins of the cornea, the remainder of the iris being stretched toward the area of attachment to the corneal scar. Lacerating wounds of the iris are often followed by infection which in time involves the whole eyeball; and where this does not occur, participation of the ciliary body in the injury renders the prognosis grave by reason of the risk of sympathetic inflammation arising in the second eye. Where a patient has lost the sight of one eye from a wound of this character, and will subsequently live beyond the reach of expert attention, it is often well to urge immediate enucleation of the injured eye as a prophylactic measure. An attempt to save the eyeball should be conditional upon the patient clearly understanding the risk involved. In every case of penetrating injury the eye should be brought as soon as possible completely under the influence of atropine. Even where infection does not arise, such eyes frequently continue to have pain until a one per cent. solution of atropine has been instilled for twenty-four hours or so at the rate of three or four instillations per diem. An occlusive bandage is usually necessary during at least the first two or three days. But when the corneal wound has once closed the eye is likely to progress more favorably if left uncovered, although a deep-smoked or amber glass will have to be worn in bright light. Displacements of the iris occur in severe injuries. The iris may be folded back upon the ciliary processes, in which case there is usually also a dislocation of the lens. Or the iris may be completely separated from its insertion, but still lie within the eyeball.

Foreign bodies may become lodged in or upon the iris. When the particle is of steel or iron, it may be dislodged by he help of the giant or hand magnet. Or it may be possible to remove a foreign body by means of forceps inserted through a small incision at the periphery of the anterior chamber. Or in some cases it may become necessary to excise the portion of the iris in which the foreign body is embedded.

Hyperemia of the Iris.—Some text-books devote special description to hyperemia of the iris as distinct from inflammation.

Hyperemia of the iris is a preliminary to all inflammatory conditions of the iris, and occurs incidentally in a number of disturbances in other parts of the eye, such as conjunctival, corneal, scleral, ciliary, and choroidal affections, including trauma. Its recognition is therefore usually of little importance as separate from the diagnosis and treatment of these conditions. An iris whose blood-vessels are dilated beyond the normal tends to show a slight change in color, blue irides acquiring a greenish tinge, and brown irides deepening in tone. The pupil may be slightly contracted, may be sluggish in its reactions, and may respond less readily than usual to the action of a miotic. Such changes, if marked, may suggest the use of atropine in addition to the measures which are otherwise employed for the general ocular condition.

Iritis.—*General Considerations.*—The difficulties of classification are well illustrated in dealing with inflammations of the iris and of other parts of the uveal tract. The iris is merely a specialized portion of this general coat of the eyeball, of common embryologic origin with the ciliary body and choroid, nourished largely from the same system of blood-vessels, and controlled by nerve endings whose relationship with those of the other parts of the uveal tract is of the most intimate possible character. It is not, therefore, surprising that a fine distinction cannot usually be drawn between iritis and cyclitis and the combination of both known as iridocyclitis, nor that any disease of the choroid or ciliary body is apt to be reflected upon the iris, and *vice versa*. The iris is further liable to involvement in various diseases of the cornea and sclera, and to a less extent of the conjunctiva. The serious consequences of iris inflammations as regards vision depend upon the opacities of the ocular media which usually accompany them, upon the changes which may simultaneously or secondarily occur in the choroid and retina, and upon the tendency to glaucoma which sometimes follows iritis.

Causes of Iritis.—Among disturbances of super-

ficial structures, the two conditions which most frequently give rise to a more or less severe secondary iritis are serpent corneal ulcer and interstitial keratitis. Conjunctivitis due to streptococcus or pneumococcus is sometimes complicated by iritis, the toxins produced by these organisms appearing to be especially capable of reaching the aqueous through the intact cornea. From the sclera tuberculous, syphilitic, and so-called gouty inflammations may extend to the iris. The occurrence of iritis as secondary to various forms of choroiditis and cyclitis has been mentioned. Among the primary inflammations of the iris, syphilis plays by far the most important part, the proportion being variously placed at from 50 to 75 per cent. A very large group of cases belongs to the class formerly described as of rheumatic origin, but really having nothing to do with rheumatism properly so called. With greater refinement in methods of diagnosis these cases will probably be gradually shown to depend upon hitherto unrecognized toxemias or bacteriemias from widely different sources, among which may be included intestinal stagnation, diseases of the nasal accessory sinuses, diseases of the lymph structures in the throat, and diseases of the teeth. A good deal has already been written pointing to the connection of pyorrhea and other dental affections with obscure disease of the uveal tract. As further causes of primary iritis may be mentioned gonorrhea, tuberculosis, diabetes, exanthematous disease, herpes, and trauma. In sympathetic ophthalmia the iris is involved in the general plastic uveitis. Persistent eyestrain is probably a predisposing factor in the causation of iritis, as in other ocular affections.

Pathology of Iritis.—The tissue changes in iritis naturally vary to some extent with the underlying cause. Although the classification of iritis into serous, fibrinous or plastic, and suppurative is largely of an artificial character, it represents a variation in the character of the exudation produced. In the first variety, when well marked, cellular exudation is very slight in amount, and the amount of fibrin thrown out is also minimum. In the plastic or fibrinous form, while pus cells may not be numerous, fibrin is abundantly produced, and adhesions are therefore particularly likely to occur. In the suppurative form there is also a good deal of fibrin, but its significance is overshadowed by the marked tendency to accumulation of polymorphonuclear leucocytes or pus cells, often mixed with large numbers of bacteria. In all forms the blood-vessels of the iris are engorged and the stroma swollen, and there is an infiltration of

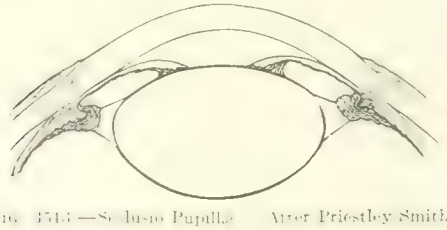


Fig. 3543.—Seclusio Pupillæ. (After Priestley Smith.)

the tissues with small round cells. These last may be the only cellular exudate present. In some forms of iritis, such as the tubercular or syphilitic, the small round cells have a decided tendency to accumulate so as to form nodules, and the other cell clusters typical of tuberculoma and syphiloma tend to occur. In tubercle and gumma necrosis is of course likely and especially in tuberculosis. The fibrinous exudates thrown out in iritis may permanently damage the eye by the formation of posterior synechiæ, as fibrinous adhesions between the pupillary margin and the lens capsule are called; by the formation of a membrane which adheres to the lens and obstructs the passage of light through the pupil; or by a combination of both effects, the pupil being closed to the passage of light and the pupillary margin of the iris at the same time completely bound down to the lens (see Figs. 3543 and 3544). The existence of an opaque inflammatory membrane is known as occlusion of the

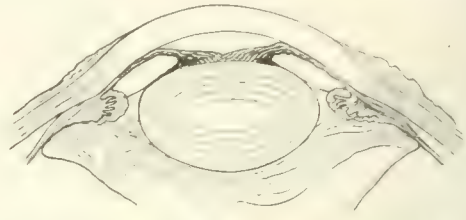


Fig. 3544.—Occlusio Pupillæ. (After Priestley Smith.)

pupil, and complete adhesion of the sphincter margin of the pupil as seclusion of the pupil. The latter is likely to favor a tendency to recurring attacks of inflammation, the final outcome of which, if not arrested, is glaucoma and blindness. In such cases the whole iris is ballooned forward by pressure of the aqueous within the posterior chamber; its normal flow into the anterior chamber being of course obstructed. This ballooning is also known as iris bombé (Fig. 3545). Organization also occurs in the exudate in the iris stroma, and subsequent contraction of this new connective tissue may cause obliteration of the blood-vessels of the iris, with resulting atrophy of

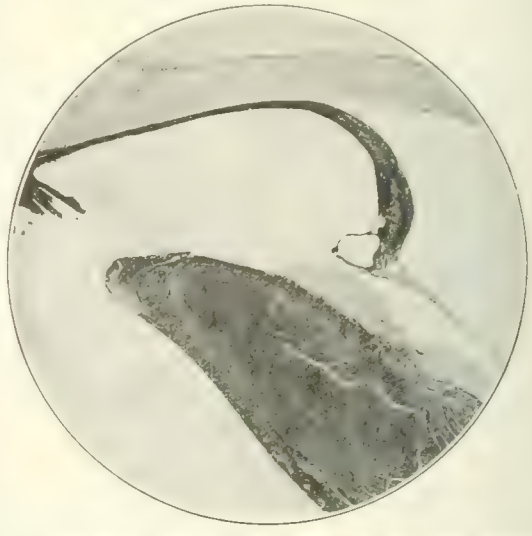


Fig. 3545.—Iris Bombé. Very extensive peripheral anterior synechia; posterior synechia with seclusio pupillæ; inflammatory pupillary membrane with occlusio pupillæ. (From Parsons.)

the tissues normally present. Atrophy and contraction of the iris stroma following inflammation may produce the condition known as acquired *ectropium uveæ* (see Fig. 3546). As in any other engorged part, minute hemorrhages into an inflamed iris frequently occur.

Symptoms of Iritis.—The leading symptoms of iritis are pain, pericorneal injection, hyperemia, discoloration, and blurring of the surface details of the iris, contraction and sluggish reactions of the pupil, adhesions of the iris to the lens capsule, cellular deposits on the posterior surface of the cornea, or in the anterior chamber, visual disturbance, and variations in intraocular pressure.

Pain may at times be almost or even entirely

absent, but is usually marked, and may be of the utmost severity, making it impossible for the patient to sleep without the use of opiates. When severe the pain radiates over the forehead, temple, and cheek.

Pericorneal injection may be practically absent in some cases of tuberculous iritis, as well as in some

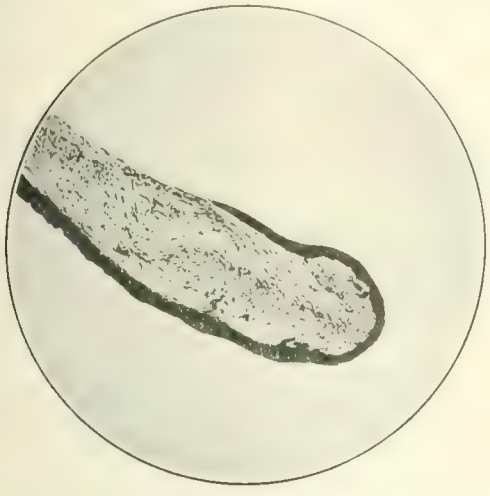


Fig. 3546.—Ectropion of Uveal Pigment, and also of Sphincter Iridis.

cases of so-called creeping or slow iritis, where the remaining symptoms are at times very slight. Pericorneal injection is distinguished from a general congestion of the bulbar conjunctiva by being pronounced next to the cornea and fading toward the equator of the eyeball, and also by having a purplish tinge which is contrasted with the brighter red of conjunctival hyperemia.

The changes in color and appearance of the iris are due to swelling of the iris stroma and engorgement of its blood-vessels. A blue iris tends to assume a greenish tint. The increase in volume of the iris also plays some part in the contraction of the pupil, although this is probably due mainly to an increased irritability of the nerve endings.

In slowly developed cases of iritis, without marked inflammatory reaction, the diagnosis may not be finally determined until an attempt has been made to dilate the pupil with atropine or some other mydriatic. When this is done such cases will usually be found to show distinct adhesions of the iris to the lens capsule, manifested by the pulling away of those parts of the iris which are not firmly attached, and the resulting irregular contour of the pupil.

The punctate deposits observed on the posterior surface of the cornea in iridocyclitis consist of collections of small round cells. Some of these are apt to be invisible without the use of a magnifying loupe, while others may be readily seen with the naked eye at some little distance from the patient. These deposits tend to arrange themselves in the form of a triangle lying somewhat below the center of the cornea. They are usually absorbed after the inflammation has subsided, but if very extensive may become more or less organized, and persist as permanent opacities, particularly evident toward the limbus below, and nourished by blood-vessels from the conjunctiva.

The mixture of fibrin and leucocytes commonly known as hypopyon, and seen as an apparent accumulation of pus at the lower part of the anterior chamber, is derived from the blood-vessels of the iris, is usually of semi-solid consistency, and not infrequently is entirely free from bacteria.

The earlier stages of an attack of iritis or iridocyclitis are sometimes accompanied by marked rise in the intraocular tension, usually of rather short duration, and perhaps due to blocking of the angle of the anterior chamber by the cellular and albuminous exudates abnormally present in the aqueous humor. In the later stages of any form of uveitis, unless special conditions have favored the development of secondary glaucoma, it is more common to find the ocular tension below normal.

Diagnosis.—In the treatment of a case of iritis, valuable time is frequently lost by mistaking the case for one of conjunctivitis. It should be remembered that in the latter disease the vision is very seldom decidedly affected; that the pupil reactions do not differ appreciably from those of the normal eye; that the hyperemia of conjunctivitis is most marked at the periphery, diminishing toward the cornea; that discharge is usually abundant in conjunctivitis and scanty in iritis; and that the pain in conjunctivitis is commonly of a burning and scratching character, and does not have the qualities of a neuralgia extending to the supraorbital, temporal, and facial regions. In phlyctenular conjunctivitis the presence of the characteristic leashes of blood-vessels should avoid confusion. In keratitis, careful use of oblique illumination and of the ophthalmoscope will usually determine some distinct focus of corneal infiltration, and the changes in the iris itself are absent.

More fatal than the confusion of iritis with conjunctivitis is the diagnosis of glaucoma as iritis. The chief points of distinction between these two conditions are (1) that the pupil in an untreated iritis is contracted, in glaucoma almost always dilated; (2) that the minute deposits on Descemet's membrane are not present in glaucoma, although there may be marked haziness of the cornea; and (3) that the tension in inflammatory glaucoma is always decidedly increased. In cases of serous iridocyclitis, in which some doubt as to diagnosis from glaucoma may exist, it should be remembered that the presence of even small vitreous opacities is distinct evidence in favor of a uveal inflammation.

Varieties of Iritis.—The distinction between serous, fibrinous, and suppurative iritis has been considered under Pathology. *Serous iritis* probably always occurs in combination with cyclitis, so that the process is best considered as a serous iridocyclitis. Such disturbances usually run a more or less chronic and insidious course. On examination with the naked eye and by ordinary light the only change visible may be a slight pericorneal injection, although even this may

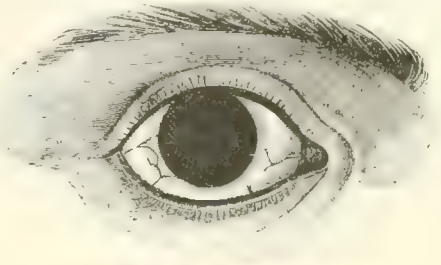


Fig. 3547.—Serous Iritis. (Noyes.)

be absent. With the magnifying loupe, and by oblique illumination, it may be possible to discover fine deposits on the posterior surface of the cornea (see Fig. 3547) and also at times some dilated blood-vessels on the surface of the iris. The more the disturbance of the ciliary body predominates over that of the iris, the less likely is the pupil to become noticeably contracted.

In *fibrinous iritis*, early instillation of a mydriatic will usually break up the new-formed fibrinous adhesions between the iris and lens. But if the process has gone on long enough for the fibrin to have been replaced by new connective tissue it may be

impossible to accomplish much or any separation of the adhesions. Yet a pupillary membrane or "cicatrix" which has apparently produced complete occlusion of the pupil with almost complete permanent loss of vision, may subsequently stretch so considerably at its attachment to the iris as to allow of recovery of an important fraction of normal visual acuity.

Serous and fibrinous iritis and iridocyclitis are found particularly in the class of cases formerly attributed to the gouty or rheumatic diathesis, that is to say of obscure endotoxic origin; and also in cases of chronic gonococcic infection, and during or after various infectious diseases, such as influenza, typhoid fever, and pneumonia. The so-called gouty and rheumatic iritis, as well as that due to the gonococcus or its toxins, are especially subject to relapses and recurrences. In a few cases recorded, the patient had suffered many years earlier from a gonorrheal urethritis from which he had to all appearances entirely recovered long ago. Yet there had been numerous attacks, usually bilateral and more or less alternating between the two eyes, of a subacute form of iritis with some adhesions, moderate disturbance of vision, and fairly prompt recovery under atropine. Tardy examination of the secretion from the prostate or seminal vesicles, obtained by special methods, revealed the presence of active gonococci, and treatment with antigonococcic vaccine resulted in permanent relief from the attacks of iritis.

Syphilitic Iritis.—The proportion of all cases of iritis in which the underlying cause was syphilis has been variously estimated at from thirty to seventy-five per cent. According to different writers, the percentage of syphilitic subjects who develop an iritis at some time during the course of the general disease is placed at from 0.42 to 5.37. Generally speaking, the shorter the interval which has elapsed since the primary infection, the more likely the syphilitic reaction in the iris is to be accompanied by marked edema and abundant fibrin formation; while the longer the interval since the primary sore, the more pronounced becomes the tendency to cellular and nodular changes. The mildest manifestation of syphilis in the iris is an injection of the superficial vessels during the earlier eruptive stage of the disease. The most frequent form of syphilitic iritis is characterized, in addition to general edema and fibrinous deposits, by decided swelling in the sphincter region. Such swelling and especially limited foci along the sphincter margin, should always arouse suspicion of syphilis (Krückmann). The individual nodules protrude laterally into the pupillary area, and forward into the anterior chamber, that is to say they are distinctly papular in structure. These earlier syphilitic lesions have a decidedly reddish color due to the marked hyperemia accompanying them, whereas the later lesions of the disease have a grayer or more yellowish appearance. In somewhat rare instances the syphilitic focus lies in the more peripheral parts of the iris, and in this event the ciliary body is always involved, and the nodules tend to group themselves in one sector of the iris. The farther from the pupillary border, the larger the nodules tend to be.

The serofibrinous form of syphilitic iritis occurs most frequently in the third stage of the disease, and is probably always a part of a general uveal inflammation. It may be due to either congenital or acquired syphilis. When congenital it occurs between the ages of five and thirty-five years. Gummatous iritis is always a tertiary lesion, and may be due to either congenital or acquired syphilis. As a manifestation of the latter it is not ordinarily encountered before adult life. It more commonly affects the ciliary than the pupillary border of the iris, is monocular, and appears as a rapid growth first noticeable within a few days of the onset of the general ocular symptoms. The pain is often mild, although sometimes very severe.

The duration of any syphilitic lesion of the iris depends, of course, upon the length of time which elapses before the patient is brought successfully under the action of antisyphilitic remedies. On subsidence of gumma a scar, sometimes of quite considerable size, is left in the iris.

Tuberculous Iritis.—In those cases of tuberculous inflammation of the iris which appear as fibrinous in character, tubercles are present but are so minute and lie so deeply in the stroma as to be clinically imperceptible. In those cases in which close observation under magnification discloses the presence of tubercles, these are still usually very minute, and are commonly irregularly disseminated over the whole of the anterior aspect of the iris, arising as they do principally in the coats of the lesser arteries, and occasionally in the capillaries of the sphincter region. There is but little difference in size between the various nodules. If the process continues, the separate nodules more or less completely coalesce. In some instances tuberculosis of the iris occurs as a larger, solitary tubercle

Fig. 3548.—Tuberculous Iritis. Iris thickened by granulomatous infiltration—Tuberculous interstitial keratitis. (From Parsons.)

appearing at the angle of the anterior chamber, simulating other neoplasms just as a gumma does, but distinguished from gumma in having an uneven surface. If not limited by treatment or spontaneous cure, this form of tubercle fills the anterior chamber and finally breaks through the cornea. (See Fig. 3548.)

Tuberculosis of the iris occurs most frequently with tuberculosis of the lymph glands, especially those of the mediastinum and mesentery; less frequently with pulmonary tuberculosis; and practically never in association with joint tuberculosis. The ophthalmoreaction should be avoided in patients with ocular inflammation, as it occasionally gives rise to a dangerous reaction. Where tuberculosis of the eye is suspected the subcutaneous test is to be preferred.

Tubercle of the iris usually occurs in childhood or youth, and seldom after the age of twenty-five years. It may be mistaken for syphilis or for sarcoma of the iris. But tuberculoma is paler than sarcoma, and the diagnosis may be further established by the presence of tuberculous foci elsewhere, by failure of the disease to respond to antisyphilitic measures, and by use of the tuberculin test.

Suppurative iritis may arise with or without the actual presence of bacteria in the iris or in the pus. (Some writers prefer to speak of pus only when bacteria are actually present.) In many cases of corneal ulcer the iris is secondarily involved and pus accumu-

lates in the lower part of the anterior chamber, without any bacteria being present in the interior of the eye. The pyogenic organisms directly responsible for many cases of iritis may arise from the blood stream or by way of perforating injury. Non-perforating injury of the eyeball may at times cause a suppurative iritis directly due to microorganisms which were previously circulating in the blood, but which after the injury find here a locus minoris resistentiæ. The bacteria most frequently responsible for endogenous iritis are the staphylococcus, streptococcus, and pneumococcus.

Other Special Varieties of Iritis.—A distinct *herpes iridis* has been described by Machek as occurring in the course of herpes zoster frontalis. There was pain, and the succeeding hyperemia and inflammation were accompanied by a plastic exudation, with localized swelling of the iris tissue. The swollen parts subsequently underwent necrosis, with hemorrhage from the broken-down blood-vessels, and later cicatrization. The disease ran a course of about three months' duration. *Sympathetic iritis* is, of course, usually a part of a general uveitis, but has occasionally been described as a fairly distinct manifestation of sympathetic disturbance. *Iritis nodosa* is practically the same condition as has been described under Conjunctivitis nodosa; the hairs of the woolly bear, or Bombyx rubri, having passed through the cornea to lodge in the iris. *Diabetic iritis* is usually a staphylococcic infection, probably due to circulation of the bacteria in the blood of a patient whose general and local resistance have been greatly lowered by the systemic disease. *Slow* or creeping *iritis* is, as its name implies, a form of iritis of very insidious onset and of more or less prolonged duration, some cases lasting for many months. The cause is usually very obscure, treatment of but little use, and the outcome dubious.

Treatment of Iritis.—In a large proportion of cases, iritis calls for both constitutional and local treatment. In syphilitic iritis antisyphilitic therapy is of course indicated, either in the form of mercury, with or without iodide, or of salvarsan or "606." Although the results obtained in syphilitic eye disease with Ehrlich's preparation have varied from almost miraculous success to complete failure, it may be said that salvarsan finds one of its most satisfactory spheres of usefulness in the several forms of luetic iritis. Painful eyes whose pupils have obstinately refused to dilate under the combined influence of mercury internally and atropine locally often show very rapid improvement, with prompt dilatation of the pupil, within a short time after the administration of a sufficient dose of "606," and often within a few days the patient is to outward appearance almost entirely well. Where mercury is used the most dependable method of introduction is probably by inunction; the patient or nurse being carefully instructed as to the exact method of rubbing in the ointment. It is doubtful whether the association of iodide with the mercury is of very great benefit in most cases of iritis.

If a tuberculous etiology has once been made out, the use of tuberculin is indicated, beginning with very minute doses and gradually increasing. Most writers prefer to keep just below the dosage which produces a distinct reaction, but a few have favored the production of a mild reaction in the eye itself, although after such a reaction the interval before the next dose is given should be prolonged, and it is well not at once to increase the amount given. All the general measures for the treatment of tuberculosis are likely to benefit a tuberculous iritis, although if the patient is out of doors some kind of protective glasses, such as London smoke, amber, euphos, or Fieuzal, will be necessary.

In every case of iritis in which the symptoms are at all severe or do not respond readily to treatment, a cause of reflex or toxic irritation should be sought for in various parts of the body, including particularly the large bowel (intestinal stasis), the mouth (for the presence of pyorrhea alveolaris, decayed teeth, root abscesses, etc.), the throat (for diseased lymphoid tissue), the nose (for interference with drainage, or actual disease, of the accessory sinuses), and the genito-urinary tract (for old gonorrhea); and an attempt should be made to correct any disease thus found which may be deemed likely to influence the eye. While bearing in mind the importance of sufficient rest and of relief from excessive work and nerve tension, the patient should be encouraged to spend plenty of time out of doors and to take a reasonable amount of out-door exercise; proper regard being had to the avoidance of the glare of the sun and sky in the brighter hours of the day. Careful attention should be paid to diet.

In the class of patients commonly spoken of as rheumatic or gouty the salicylates often seem to be of material benefit, although this is possibly due rather to analgesic and diaphoretic action than to any specific influence on the disease. Intensive treatment with sodium salicylate, to the extent of as much as one grain to every pound of the patient's body weight during a period of twenty-four hours, has been highly praised by some authors for severe and painful cases of iritis. The patient must, of course, be kept at rest while such heroic treatment is administered.

As regards local treatment, the use of atropine has first place. A solution of the sulphate, usually of one per cent. strength, should be employed as often as may be necessary to thoroughly dilate the pupil and keep it well dilated, if this is possible; in most cases not less than three times daily. It is well to remember that a single drop well introduced and not immediately squeezed out by the patient is just as effective as larger quantities. Stale solutions of atropine sometimes cause an eruption on the skin of the face around the eye. Where necessary, small amounts of solid atropine may be placed upon the scleral conjunctiva in order to produce a more powerful effect, or a stronger solution may be used. In some cases of iritis it is necessary to be cautious in the use of atropine on account of a tendency to increased tension of the eyeball; and wherever such a tendency exists the tension should be measured at intervals with the Schiötz tonometer.

Next to the instillation of atropine, the most beneficial local measure for the relief of pain is the application of heat. This is ordinarily to be used in the form of hot water compresses, kept up for from five to fifteen minutes every hour or two. In hospital practice the nurse should be carefully instructed that to obtain results the water must be kept just as hot as the patient can bear. Sometimes a small hot-water bag may be kept applied outside a wet compress. Considerable relief from pain is sometimes afforded by the occasional use of dionin, either solid or in solution of from two per cent. upward. This drug itself causes temporarily a fair amount of pain, redness, and edema. The use of natural or artificial leeches, applied to the temple, is often productive of at least temporary relief from pain.

Subconjunctival injections of common salt in solutions of various strength, as well as of dionin and compounds of mercury, have also been recommended for severe cases of iritis, but the reaction produced by them is severe and often alarming, and there has been some dispute as to the advisability of their employment. Finally, a patient who has suffered from iritis should, when the attack subsides, be carefully tested as to the existence of refractive error, and the proper correction given, since eyestrain must be regarded as one of the causes leading to iris inflammations.

Iridectomy has frequently been advised as a part of the treatment of obstinate cases of chronic iritis. In many cases its use is of questionable advantage, and in poorly selected cases the patient's condition is changed for the worse by the operation. But in cases

in which there is a decided tendency to secondary glaucoma, and particularly where the anterior and posterior chambers are completely separated by exclusion of the pupil, with a marked tendency to iris bombé or ballooning forward of the iris, iridectomy is sometimes the one thing needed to save the eye and vision and prevent further relapses. If the tension of the eye is subnormal the operation is decidedly contraindicated, and in cases where the operation seems advisable it should be done if possible during a quiet interval between attacks. In cases of occlusion of the pupil, iridectomy is sometimes done to provide an artificial pupil, through which a fair measure of vision may under otherwise favorable circumstances be obtained.

The operation of iridectomy is usually performed through an incision made near the sclerocorneal junction with a broadly lance-shaped knife (lance keratome), although the incision may be made with a Graefe cataract knife. After penetrating the eye the blade is carried forward toward the center of the anterior chamber, and parallel with the surface of the iris. Through the opening thus made the iris is seized near its pupillary margin with iris forceps, drawn outside the wound, and the piece excised with iris scissors. The operation may be done under cocaine as in the combined operation for cataract extraction. If done for optical purposes, only a small piece of iris should be excised.

Tumors of the Iris.—*Sarcoma* of the iris is rarer than sarcoma of any other part of the uveal tract. Almost invariably it calls for enucleation of the eyeball, although occasionally small sarcoma of the iris has been treated by excision of the sector of the iris upon which the tumor was situated. The diagnosis is usually not difficult, although there is some danger of confusion with syphiloma and tuberculoma, and also with congenital pigment masses (melanomata) or moles of the iris. *Moles* at times, as elsewhere in the body, take on a rapid and intensely malignant growth, with pronounced tendency to metastases.

Cysts of the iris may be of congenital origin, or may arise from injury, either accidental or operative. If traumatic they are due either to closure of a crypt of the iris, with accumulation of fluid, or to transplantation of epithelium from the cornea or scleral conjunctiva. Some cysts called of the iris are not really so,

Fig. 3548.—Cyst of Iris Following Implantation of Eyelash. (From Treacher Collins.)

but merely lie in contact with the iris. Cysts may be destroyed by excision of their walls. They cause disturbance of vision by mechanical interference and sometimes give rise to inflammatory reaction. (See Fig. 3549.)

Primary *carcinoma* of the iris has been described, but is of extreme rarity.

William H. Crisp.

Irish Moss.—See *Chondrus*.

Iron.—See *Ferrum*.

Irondale Springs.—Preston County, West Virginia.

Post-office.—Independence.

Access.—Viâ Baltimore and Ohio Railroad to Hardman's Siding, one and one-half miles west of Independence, thence by the Iron Valley Railroad three and one-half miles to the springs.

The Irondale Springs occupy a very attractive location about 1,200 feet above the sea-level, but the place is not at present used as a resort. The water is bottled and used commercially. The following is a recent analysis by Fraser and Company:

Hypothetical Form of Combination.

	Parts per million	Grains to U. S. gallon
Ammonium chloride	0.023	0.0013
Potassium chloride	3.536	0.206
Potassium sulphate	19.74	1.151
Sodium sulphate	12.19	0.711
Magnesium sulphate	16.425	0.958
Calcium sulphate	276.694	15.999
Sodium nitrate	16.51	0.963
Sodium tartrate	Trace	Trace
Calcium bicarbonate	14.063	0.820
Calcium silicate	22.629	1.317
Iron oxide and alumina	1.50	0.088
Mangano-manganic oxide	1.20	0.070
Silica	0.47	0.027
Total	384.980	22.3113

This water, as shown by the analysis, is exceptionally rich in manganese, besides containing a large amount of alum. It is said to possess tonic and diuretic properties. It is also sedative to the gastric mucous membrane, and acts well in the nausea and vomiting of pregnancy, and has been found useful in chronic diarrhea. In Bright's disease and in anemia and chlorosis it has seemed to possess value. It is a clear, soft, odorless, palatable drinking water, bottled and largely distributed under the name of Manacea.

Emma E. Walker.

Irradiation is the diffusion or, as one might say, "the overflowing" of the nerve impulse over the boundaries of the pathway within which it usually travels.

If a local cardiac condition gives rise to pain not only in the region of the heart but also in the arm, the latter pain is an irradiated one, belonging as it does to quite another territory than that supplied by the nerves of the heart. This irradiation of visceral pains into cutaneous areas follows definite laws which have been laid down by Head in his classical researches on this subject.

But a pain may irradiate not only from a visceral or sympathetic to a cutaneous or other cerebrospinal nerve territory; it may also irradiate from one nerve to the other or from one branch of a nerve to the other *within* the cerebrospinal system. For instance, pain arising from a partial lesion of the second branch of the fifth nerve (toothache) may spread not only over the entire second branch, but even over the third branch of that nerve. A pain may also irradiate from one side to a (usually symmetrical) point on the other side of the body.

While it has thus been customary to apply the term irradiation to conscious sensory impressions, which need not necessarily be painful, there is no reason why it should not be applied to motor and reflex innervation as well, the physiological process and its anatomical basis being probably the same. For instance if tapping of the patellar tendon which normally causes a contraction only of the quadriceps muscle of the same side, produces also muscular contractions in the other lower extremity, as is the case in many organic cerebral and particularly spinal lesions, we certainly have the right to speak of it as irradiation.

Similarly the associated movements often accompanying motor acts, for instance, movements of the jaw accompanying the act of cutting with scissors or of cracking nuts, should also be classed under the heading of irradiation.

The small space allotted to this article does not allow us to enter on the mechanism of irradiation further than to say that it must take place at the points of passage from one neuron to another, the multiplicity of connections of each neuron giving a wide range of possibilities in this direction, especially if it is considered that in every case a chain of at least two neurons must be passed before the stimulus reaches its final destiny. B. Onuf (Onufrowicz).

Literature.

Henry Head: Die Sensibilitaetsstoerungen der Haut bei Visceralerkrankungen Translated by Dr Wm Seiffer, Berlin, 1898, Verlag von August Hirschwald Also articles in Brain, vol xvi., part i., 1893; vol. xvii., part iii., 1894; vol. xix., part ii., 1896; and vol. xxiv., 1901.

Irritability.—Irritability may be defined as the quality possessed by living tissues, animal as well as vegetable, of reacting toward stimuli* with manifest dynamic changes, or, as Verworn puts it, with changes of the vital processes. The nature of these changes in the case of the nerve protoplasm has been made a subject of special study by A. F. Mathews, the result of whose researches was published in the *New York Sun*. He concludes that "nerve protoplasm" is stimulated (*i.e.* excited) by the passage of colloidal particles from a condition of solution to that of gelatination. The irritability of a nerve is diminished whenever the solution of the colloids is rendered more permanent. It increases as the nerve approaches the state of gelatination. These changes may become apparent directly or indirectly, in the form of muscular contraction, glandular function, sensory perception, ameboid movements, flagellate movements, or streaming of protoplasm, or in other ways.

The dynamic changes produced by the stimulation may manifest themselves in the stimulated tissue itself or be inferred indirectly by the effects upon other tissue. For example, the dynamic alterations wrought by stimulation of a motor nerve may find an indirect expression in the form of a muscular contraction; but their presence in the nerve may be demonstrated also directly by the so-called "current of action" or "negative variation," produced in the nerve by the stimulation, and demonstrable with a galvanometer.

This latter direct method is the more accurate one, giving a truer measure of the irritability of the stimulated tissue. A study of the action of curare convincingly demonstrates the truth of this statement. Curare acts on the motor nerve endings in such manner as to abolish the faculty of transmission of the nerve impulse from nerve to striated muscle. Stimulation of the nerve remains, therefore, without effect on the muscle, but the muscle continues to respond promptly to direct stimulation. That the nerve too retains its irritability is shown by the fact that its stimulation, be such of a mechanical or chemical or electric or other nature, gives rise to a "current of action" demonstrable by a galvanometer.

In a case of slight curare poisoning the faculty of transmission of the impulse from nerve to muscle is not entirely abolished, but only impeded more or less according to the severity of the poisoning, so that strong stimulation of the nerve will produce only a slight muscular contraction. Nevertheless the irritability of the nerve remains unimpaired, as shown by the "current of action." Consequently if in this case we were to measure the degree of irritability of the nerve by the effect of its stimulation on muscle, we should clearly come to a wrong conclusion.

However, the method of direct measurement of the irritability of a tissue is often practically not feasible, and we then have to resort to the *indirect* method in spite of its fallacies.

The degree of irritability of a tissue is expressed by the inverse proportion between the strength of the stimulus and the demonstrable or manifest dynamic change produced. It may be expressed by the formula: $I = \frac{D}{St}$ in which I denotes irritability while the denominator St represents the stimulus, and the numerator D the demonstrable dynamic change produced by it. (Verworn.)

In many cases the disproportion between the strength of the stimulus and the amount of demonstrable dynamic changes wrought by it is very great, the amount of energy evolved by the stimulation being often ten times or even hundreds of times greater than the amount of energy represented in or spent by the stimulus itself.

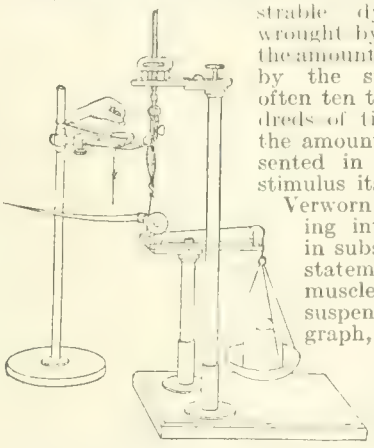


Fig. 3550.—Mechanical Contrivance for Demonstrating the Disproportion between Stimulus and Effect of Stimulus. (From Verworn.) For details see the text.

Verworn gives the following interesting instance in substantiation of this statement: "A nerve-muscle preparation is suspended on a myograph, the muscle is loaded with a weight of 100 grams and its nerve is laid over a glass plate supported by a stand (Fig. 3550). Upon the nerve rests a small aluminum pan having a sharp keel on the lower side, and into this a weight of 10 grams falls from a height of about 10 centimeters. At the moment of stimulation the muscle contracts and raises the 100 grams about 1 centimeter. Here the quantity of energy that corresponds to the work of the muscle is approximately ten times greater than the quantity of energy that has operated as a stimulus upon the muscle."

A very striking parallel fact from the inorganic world is familiar: The spark from a small battery which, applied to the human body gives a hardly noticeable sensation, is sufficient to blow up a whole house if applied to a definite quantity of nitroglycerin in the proper manner.

In accordance with the law of the preservation of energy this disproportion must be explained, not by the addition of energy not before existent, but by the transformation of one form of energy into another form—for instance, of chemical energy into physical energy.

However, while in the instance of the spark exploding the nitroglycerin, the produced effect is to a great degree independent of the size of the "stimulus," inasmuch as a small spark applied to a certain quantity of nitroglycerin will produce no less explosive effect than a large flame applied to the same quantity, this does not hold true or at least is not the rule for the phenomena of irritability in animal and vegetable life. Here—and this is especially true for the nervous and muscular systems—very frequently the manifest dynamic change produced by a stimulus increases with the size of the latter, but only up to a certain point; beyond that point it rapidly diminishes and the stimulus then rapidly reaches that size which causes death of the tissue.

The attempt to establish the exact ratio between intensity of stimulus and degree of response has been made by Weber, Fechner, and others.

* A definition of *stimulus* is given in a later section of this article.

According to *Weber's law* the amount of cutaneous pressure necessary to produce perceptible increase of sensation always bears the same ratio to the amount of the stimulus already applied.

Fechner found that the sensation increases in intensity in arithmetical progression, whereas the intensity of the stimulus increases in geometrical progression, this relation being expressed in *Fechner's law*, which states that "the intensity of sensation varies with the logarithm of the intensity of the stimulus."

More and more evidence, says Verworn, has accumulated, however, to the effect that the *Weber-Fechner law* cannot be formulated into a general mathematical law, fixing the relations of the stimulus and the intensity of the response.

For a great number of "living systems" Verworn finds that with the increase of the intensity of stimulation the response at first increases rapidly and later more and more slowly.

In several forms of living substance every stimulus which acts at all, always produces a maximal response. This relationship, called the "*all or none law*" (Bowditch, Verworn) has been stated by Bowditch to exist for the frog's heart, by McWilliams for the mammalian heart, by Gotch for the constituent fibers of a nerve, by Keith Lucas for the single cross-striated fiber of the skeletal muscle, by Veszi for the strychninized spinal cord. This law may prove to be of more generalized application.

That in case of stimulation of a nerve, strong stimuli produce stronger effects than weak ones, Gotch explains by pointing out that with increasing intensity of the stimulus a greater and greater number of fibers of the nerve are stimulated, and Keith Lucas makes the same explanation for the effect of direct stimulation of skeletal muscle and Veszi for that of the strychnine-poisoned ganglion cells of the posterior horn of the spinal cord.

Here a definition of the term *stimulus* is in order. In harmony with the definition of irritability, a stimulus may be defined as any agency which is capable of producing manifest or demonstrable changes of dynamics in the tissue on which it acts; changes that may be directly demonstrable in the stimulated tissue itself or indirectly by the effects on some other tissue, as has already been explained in the case of nerve and muscle.

This definition comes very near that of Verworn,* who distinguishes the vital phenomena as spontaneous phenomena—when all the external conditions remain unchanged, and phenomena of stimulation—when other influences act upon them, and who accordingly defines a stimulus as every change of the external agencies that act upon an organism. This definition has been slightly modified by us in view of the fact that, as Verworn himself remarks, a strict dividing line between spontaneous phenomena and phenomena of stimulation cannot be drawn. Wherein our definition corresponds with that of Verworn, however, is that both depressive as well as exciting agencies are included in the definition of stimuli, and this is perfectly appropriate if one considers that in many cases it is very difficult, if not next to impossible, to state whether the effect of the stimulation is depressive or exciting. In this connection the existence of inhibitory nerve fibers and nerves should be called to mind, the excitation of which produces a depressive instead of exciting effect on the tissue (muscular, glandular, etc.), which it innervates, and yet the agency which thus acts on said nerve or nerve fibers must be called a stimulus.

As to the kinds of agencies that may act as stimuli, such are very numerous and may be, according to Verworn, classified into chemical, mechanical (including sound vibrations), thermic, photic, and electrical.

Another distinction to be made is between the *exciting* and the *depressing* effects of a stimulus, by which is meant the increase or diminution respectively of the activity or function of the stimulated tissue. Almost every kind of stimulus probably may have either effect, according to the intensity, duration, and other attributes of the stimulus.

Nature of the Phenomena of Excitation and Depression.—In discussing the nature of the phenomena of excitation and depression Verworn points out the importance which oxydative processes play in the phenomena of excitation and lack of oxygen in the phenomena of depression. He also accentuates the rôle of oxydative decomposition as the chief source of energy production. Whereas the stimuli which produce an exciting effect may be of very different kind, they all invariably increase the oxydative disintegration of the living system on which they act. The depressing stimuli on the contrary, while also of various kind, have in common a lessening of the processes of oxydative disintegration owing to a relative or absolute deficiency in oxygen.

In the measure in which the amount of oxygen available for the oxydative disintegration attendant upon excitation becomes diminished, irritability decreases, that is, depression takes place. In the same degree in which oxydative disintegration becomes less, anoxydative breaking down products are accumulated. Their accumulation likewise plays a part in the production of depression.

Every excitation is followed by a period during which irritability is lessened and which is called the refractory period. By the metabolic self-regulation, in accordance with the principle of chemical equilibrium the original metabolic equilibrium is restored after each excitation, but if the processes of disintegration and self-regulation are delayed either by want of substance necessary for breaking down, particularly a lack of available oxygen, or by accumulation of decomposition substances, the refractory period is prolonged and the responses to every further stimulation decreased, that is, the system is fatigued.

Fatigue is therefore a typical state of depression based in part on relative deficiency of available oxygen, or a true asphyxia.

In *Narcosis* a suppression of oxydative processes occurs in the living substance acted upon by the narcotic, and Verworn formulates the following hypothesis on the manner of this suppression:

"The narcotics obstruct either by absorption or by loose chemical combination the oxygen carriers of the cell and render them incapable to actuate the molecular oxygen. In consequence oxydation of the oxydable substances cannot take place and disintegration occurs of an anoxydative form. The cell asphyxiates.

These oxygen carriers are, according to the theory of Mansfield and others, represented by the lipoids of the cells and the narcotics by their accumulation in the lipoids bring about asphyxiation by obstructing the transmission of the oxygen from the outer medium through the surface layer of the lipoid into the protoplasm. This conception harmonizes well with the observations made by Meyer and Overton, that the depressing effect of a narcotic is the greater the larger is the coefficient between substances of a fatty nature and water, or in other words, that those narcotics produce the strongest effects which are most readily soluble in substances of a fatty nature (such as the lipoids are) but not so in water.

"While thus," says Verworn, "suppression of oxydation has been shown to be the moving factor in the depression produced by narcotics, there are oxydation suppressing substances, which are not narcotics as they do not follow the Meyer-Overton law,

*Verworn, in his recent extensive monograph bearing the title "Irritability" (New Haven, 1913), defines stimuli as alterations in the external conditions and irritability of living substance as the capability to respond to stimuli by changes of the vital processes, a definition very similar to the one given by him previously, as quoted above.

above mentioned, and it is likewise certain that depressing substances will be found, the depressing effects of which will not have their point of attack in the oxygen exchange but will be shown to exist in other constituents of the metabolic chain.

Kinds of Stimuli and Responsiveness to Them.—The responsiveness to all kinds of stimuli can be traced down to the lowest forms of life in the animal scale and as seen also in plants. As an instance of the irritability of certain plants to mechanical stimuli, one may mention that of Mimosa pudica, the leaves of which fold together when the plant is shaken; or, again, electrical currents have been seen to increase granular streamings in protoplasm of plants, such as Nitella and Tradescantia (quoted from Verworn).

No less interesting is the narcosis of plants as observed by Claude Bernard, who found that under the influence of chloroform certain Algæ (spirogyra) cease to evolve oxygen, certain Diatomeæ cease to secrete, and growth and division of plant seeds become arrested; while *Mimosa pudica*, when under the influence of ether, entirely closes its above-mentioned responsiveness to mechanical stimulation.

The effect of mechanical stimulation on bacteria was shown by Horvath (confirmed by Meltzer), who observed not only inhibition of growth but even death and granular disintegration of these microorganisms as the result of regular vibrations.

That bacteria too may be excited by light is shown in the *Bacterium photometricum*, the flagellum of which moves under exposure to light, but ceases to move when the amount or intensity of light diminishes beyond a certain level.

In amebæ and ameba-like rhizopods responsiveness to all kinds of stimuli—chemical, mechanical, thermic, photic, and electric—has been seen by Engelmann, Max Schultze, Kühne, Verworn, and others. (See Fig. 3551.)

The ciliary and flagellar motion or infusoria too has been found to be influenced by all the above kinds of stimuli in the direction of acceleration as well as that of retardation. Narcotics, such as ether and chloroform, retard this movement (Engelmann); high temperatures up to a certain point accelerate and low temperatures retard it.

An adaptability of ameba-like organisms to stimuli of all classes, brought about by gradually increasing the amount of stimulation, has been demonstrated by Engelmann. This author noticed particularly that Actinospherium, a rhizopod, if placed in salt solutions of gradually increasing strength, could finally be made to extend its pseudopodia in solutions of such concentration as would have made it contract immediately to a ball and eventually would have produced death, had it been brought into them directly.

A parallel phenomenon in higher animals is observed in the adaptability of the organism to such poisons as morphine and the like.

However, this adaptability is by no means the rule, since in the case of the rectal and vesical sphincters, for instance, as Verworn points out, the response continues the same in spite of the prolonged stimulation to which they are subject.

In the course of evolution of the animal series the use of organs or tissues for particular purposes leads to such a differentiation that each organ or tissue becomes excitable particularly by a definite kind of stimulus. An instance of this is the retina, the exquisite responsiveness of which to photic stimuli makes it adapted for the purpose of vision. This is, however, not due solely to the photic responsiveness of the retina, but is greatly furthered by the refractive apparatus of the eye and the arrangement of the retinal elements, which make it possible to concentrate, differentiate, and isolate the stimulations in the most perfect manner for the particular purpose of vision.

Moreover, experiences with the Röntgen rays have convinced us that even in the highly differentiated organism of man the retina is not the only tissue that can be stimulated by light. The deep trophic cutaneous disturbances following long exposures to this kind of light bear out this statement; and similarly, sound vibrations, although finding a particularly responsive recipient in the peculiarly constructed auditory apparatus of the labyrinth, evidently also have some effect on other tissues.

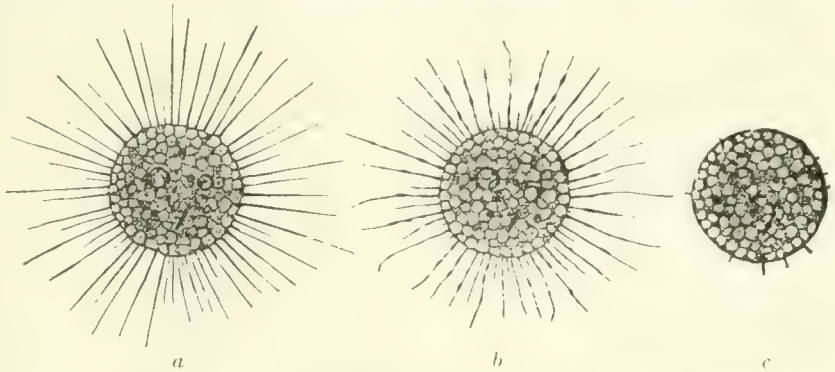


Fig. 3551.—Actinospherium under Chemical Stimulation (From Verworn) *a*, Unstimulated, *b*, slightly stimulated, *c*, strongly stimulated

The irritability par excellence of nerve tissue is shown among other things by comparison with that of amebæ, since nerve fibers are put into activity by extremely feeble galvanic currents, while amebæ demand much stronger currents for this effect.

Relation of Irritability and Conductivity.—The irritability and conductivity of a living substance or system are inseparably linked to each other. For Rhizopods, Verworn demonstrated that the conduction of excitation takes place with a decrement of intensity and rapidity, becoming larger with the distance from the point of stimulation until the wave of excitation is obliterated, whereas his manifold observations on the medullated nerve showed that the latter under normal conditions conducts excitation without a perceptible decrement of the intensity.

These great differences in the conductivity of excitation are conditioned by variations in the degree of irritability, and the three factors—irritability, intensity, and velocity of the progress of the wave of excitation are inseparable, as is the existence of the "all or none law" found valid for the normal nerve, in which the weakest, as well as the strongest stimuli produce excitations of equal intensity.

Finer Mechanism of Conductivity.—The progression of excitation from cross-section to cross-section in a living system is according to Verworn brought about by decomposition of the molecules in one region acting as a stimulus and producing a disintegration of the molecules in another (meaning adjoining) region, etc. It can in many respects be compared with the burning of a fuse, but since in the case of the excitation of living substance the production of heat, which in the fuse plays such an important rôle, is very small.

"It seems easier to assign the rôle of mediator of disintegration not to heat but to electricity."

Verworn considers the numerous combinations and speculations of Bethe and Apathy concerning the part taken by the neurofibrillæ in the process of conduction as untenable and he forms the theory that the reticulated substance is the seat of the electric discharge which in turn gives the impact to the breaking down of new molecules and with this to the occurrence of new potential differences and so on; consequently the disintegration is extended further and further through the connected masses of the protoplasmic framework.

Threshold and Threshold Value of Stimulation.—Very feeble stimuli cause no visible or demonstrable effects on the stimulated or other tissues. By gradually increasing the intensity of the stimulus a point is finally reached when its effect becomes just perceptible or demonstrable. This point is called the threshold of stimulation and the intensity of the stimulus producing this minimal effect is called the threshold value of stimulation. Or one speaks of "threshold stimulus." When the intensity of the stimulus is further increased until a point of maximal response is reached, the stimulus just sufficiently strong to produce this maximal response is called maximal stimulus, whereas all intensities between the threshold and the maximal stimulus are called submaximal stimuli, and intensities above the "maximal stimulus" are termed "supramaximal stimuli." (How to harmonize these definitions with the "all or none law" has been indicated in preceding paragraphs of this article.) This threshold value is not an immutable entity but dependent on the demonstrable effect that is expected, as well as on other factors.

For instance, the threshold value for a stimulation of the planta pedis might be that degree of stroking which is sufficient to produce a plantar reflex; or it might be that degree of stroking which just suffices to give a conscious tactile impression. The first would be the threshold value of reflex, the other the threshold value of conscious perception for the tactile stimulus.

For a motor nerve the threshold value of stimulation is usually measured by the intensity of the stimulus required to produce a minimal contraction of the muscle supplied by it; but we have seen in the instance of curare poisoning, which, by a paralysis of the endings of a motor nerve, prevents or impedes the transmission of the impulse from nerve to striated muscle, that the degree of muscular contraction does not give us any true measure of the irritability of the nerve and consequently not of the threshold value of stimulation of the nerve.

Another factor influencing the threshold value is the amount of "charging" existing in a given nerve or nerve-cell group previous to the stimulation. If, for instance, a cell group from which a motor nerve takes its origin is acted upon from some source or other by a temporary nerve impulse or by a continuous stream of nerve impulses (tonus) just weak enough not to produce a muscular contraction, then a very small amount of additional stimulation, whether such is a voluntary nerve impulse, a sensory stimulation acting by way of reflex, or an external direct stimulus, would suffice to transform the latent into potent energy and thus to cross the threshold of stimulation.

On the other hand the nerve impulses acting on a given cell group at the moment of an intended stimulation may be antagonistic to the latter and thus increase its threshold value in a corresponding degree.

B. Onuf (Onufrowicz).

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Ischl is one of the most frequented spas of Austria, being often visited by the Emperor and many of the nobility. It is situated in the center of the "Salzkammergut," in a beautiful Alpine valley, at the point where the little river Traun empties into the Ischl. Its elevation is about 1500 feet above the level of the sea. It possesses a mild, moist climate, the average temperature from May to the end of September being 61° F. Showers are very frequent during the early part of the summer, but the sandy soil absorbs the water quickly, so that the walking is seldom rendered unpleasant. In the neighborhood of the salt works the atmosphere is very similar to that of the seashore.

The salt hills of Ischl and Hallstädt contain natural salt veins, consisting of saliferous clay mixed with gypsum, resting upon limestone seamed with marl and clay. Pure water is conveyed hither in pipes, becomes saturated with the salts, and the brine then flows into the salt houses in Ischl and Ebensee. The following is the composition of the brines coming from the Ischler and Hallstädter hills, calculated in parts per 1,000:

	Hallstädter brine.	Ischler brine.
Sodium chloride	255.26	236.13
Magnesium chloride	4.94	0.93
Magnesium bromide	0.16	0.06
Potassium sulphate	4.62	0.69
Sodium sulphate	3.25	3.84
Calcium sulphate	3.40	3.84
Total solids	271.63	245.49

The baths are prepared by mixing these two brines in the proportion of one-third Ischl and two-thirds Hallstädt, to which is often added a decoction of pine needles. There are also facilities for mud baths and for inhalations of salt spray.

There are also several mineral springs at Ischl. The following is their composition, computed in parts per 1,000:

	Schwefelquelle.	Klebelsbergquelle.	Maria-Louisenquelle.
Calcium carbonate	0.092	0.015	0.197
Magnesium carbonate	.	0.011	0.010
Calcium sulphate	0.459	0.244	0.078
Potassium sulphate	0.024	0.108	.....
Sodium sulphate	4.125	0.274	0.071
Magnesium chloride	0.732	0.406	0.098
Sodium chloride	17.005	5.118	5.580
Total solids	22.437	6.086	6.034

In the sulphur spring (Schwefelquelle) there is a considerable amount of free sulphureted hydrogen gas.

In addition to its being a fashionable watering-place, Ischl enjoys a well-deserved reputation as a health resort. The climate and the waters combine to render it admirably adapted for the treatment of nervous and irritable individuals, and of those debilitated by disease, dissipation, or too rapid growth. Children suffering from scrofulous troubles are often much benefited by a visit to the place. Inhalations of the brine spray are used in the treatment of chronic catarrhal affections of the air passages, and many female disorders are relieved by brine baths.

The accommodations are of the usual good character found at frequented spas.

The beautiful situation and the mild, equable, soothing climate, and innumerable charming excursions round about, all conspire to render Ischl a delightful

spot for a longer or shorter visit in the season, which lasts from July to the end of September.

It is an excellent resort for an "after-cure." Besides the diseases above mentioned, there may be added neuralgia, anemia, and rheumatoid arthritis, which are said to improve from a residence here. It is still an expensive and fashionable resort, but the accommodations are said to be excellent. There is a fine Kurhaus, two bath houses, where brine, sulphur, and pine baths, and brine vapor baths are given. The "milk and whey cure" is also another resource of the place. The number of inhabitants is about 7,000, and there are nearly 6,000 visitors.

The shortest route from England is viâ Cologne to Munich, thence viâ Salzburg to Ischl. It is 1,048 miles distant from Paris.

Although he visited it many years ago, the writer still vividly remembers the beautifully shaded avenue which is one of the features of the place.

EDWARD O. OTIS.

Isinglass.—See *Ichthyocolla*.

Isolation.—This may be defined as the separation of a patient with a communicable disease from other individuals. There are different degrees to which the principle of isolation can be carried out. In the strictest sense isolation means the absolute segregation of the patient in a separate room. In most hospitals for contagious diseases the purpose of isolation is supposed to be fulfilled by keeping patients affected with the same disease in the same ward. Within recent years there has been a tendency to discount the importance of the aërial conveyance of infection, and to regard physical contact and the effect of droplets coughed out by the patient or of discharges from various cavities of the body as the main factors in the spread of communicable disease. In spite of the widespread establishment of isolation hospitals and the enforced isolation of patients in their own homes, there has not been a commensurate diminution in the prevalence of contagious diseases. The partial failure of isolation is to be attributed to the fact that healthy individuals may, as bacteria carriers, impart a communicable disease to other individuals more susceptible than themselves; and also to the fact that, as in the case of measles, the infected individual is not isolated until he may have already imparted the disease to others. There is a growing belief that in the prevailing or common types of infectious disease, isolation is carried too far and that less rigorous methods would be equally as effective. Charles V. Chapin, for many years Health Officer of Providence, Rhode Island, has made an extensive study of this subject and finds that the fewer the infected persons in any community or institution the more likely is isolation to be successful; that the effectiveness of isolation varies inversely as the number of missed cases and carriers; that hospitalization in such diseases as scarlet fever and diphtheria cannot be expected to exterminate them; and that the isolation of school children should be more strict than that of adults. Isolation should be stringent in the case of smallpox, and in the case of such rare diseases as plague, leprosy, and cholera. Recent investigations have shown that the infectivity of measles is greatest during the height of the catarrhal symptoms, and the experience of English hospitals has demonstrated that there is no danger of contagion from the desquamated skin in scarlet fever. In Providence, Rhode Island, the scarlet-fever patient is released from the hospital in four or five weeks if there is no nasal or aural discharge, and no heed is paid to desquamation.

The question of the nature and degree of isolation in hospitals is an important one. The "cubicle" system of bed isolation is the one best adapted for the prevention of cross-infection. In hospitals constructed on the pavilion plan in which cases of the same infectious disease are treated in the same ward, it is necessary to maintain a distance of not less than twelve feet between each bed in order to minimize the chances of contact and of droplet infection from one patient to another. Even with this provision the isolation is not ideal, for as is pointed out by H. Franklin Parsons, "there is reason to believe that in infectious diseases the primary infection is liable to have accompanying or supervening upon it other secondary or septic infections, to which latter the severity of the resulting illness and the occurrence of complications are largely due; that these secondary infections may be different even where the primary infection is the same; and that therefore every patient suffering from an acute infectious disease should be regarded as requiring to be isolated more or less completely according to the nature and stage of the disease—not only from healthy susceptible persons and from persons suffering from illness due to other infections, but also from other cases which are classified as being of the same infectious disease."

Considerable attention is now being paid to the "cubicle" or "compartment" system of isolation. There are three different types of this, according to the degree of aërial separation between the compartments: (1) Each compartment is completely separated from every other and is separately entered from the open air under a veranda, as at the Walthamstow Hospital, England. (2) Each compartment is separated from every other by a partition reaching to the ceiling, but the compartments are all entered from one corridor, as in the Pasteur Hospital, Paris. (3) The compartments are all entered from one corridor and are separate from one another only by partitions not reaching to the ceiling. These partially separated cubicles are unsuited for the treatment of smallpox, chickenpox, measles during the acute stage of the disease, and septic scarlet fever, but it is believed that scarlet fever not of a septic type, diphtheria, measles in the posteruptive stage, whooping cough, mumps, influenza, and typhoid fever can be treated in such a cubicle without much risk to other patients in the ward.

ALEXANDER SPINGARN.

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Isospora.—*Cytospermium*. *I. bigeminum* is a sporozoan parasite that lives in the intestinal villi of dogs and cats. It is believed to occur in man sometimes. See *Protozoa*. A. S. P.

Itch-mite.—See *Arachnidæ*.

Ivy.—*English*, *Black*, *Creeping*, or *Common Ivy*. *Hedera*. The herbage and fruit of *Hedera Helix* L. (*H. poetica* Salisb., fam., *Araliaceæ*). The gum resin exuded by the stem is also used.

This well-known and highly ornamental evergreen is native of Europe and temperate Asia, and is cultivated in all countries having a suitable climate. The leaves are stoutly petioled, from three to six inches long, and mostly of greater breadth, entire or palmately three- to five-lobed, rounded or cordate at the base, acute at the summit, smooth, very dark green, very thick and coriaceous, somewhat aromatic and of an astringent and disagreeably bitter taste. The poisonous fruits are in long-peduncled, panicled umbels and are five-pyrenate berries, smooth, black, and internally mealy. They have a terebinthinate odor when bruised and a pungent, somewhat sour, terebinthinate taste. The leaves contain a little volatile oil, tannin, and the glucoside *helixin*, which yields

helixigenin. The fruit contains a bitter-sweet resin in the pulp, and several specific principles in the seeds, namely *hederic acid* ($C_{16}H_{26}O_4$) and *hederotannic acid.* A bitter body, *hederin,* has been reported, but its nature is unknown. It has been claimed that it is identical with the hederotannic acid, but this appears unlikely. The emeticocathartic and poisonous properties have been proven by Joanin to reside in the hederin.

Ivy leaves have been used, bruised into a poultice-like mass and in other forms, as a parasiticide and a stimulating application to cutaneous ulcers and eruptions. They are also used internally in doses of gr. xv.–xxx., in various diseases and wholly unscientifically. The fruits are emeticocathartic and are doubtless effective as a nauseating diaphoretic, and have thus been used in febrile states. The gum resin is used as an astringent internally, and externally for the same purposes as the leaves. HENRY H. RUSBY.

Ivy, Poison.—See *Rhus toxicodendron.*

Ixodes.—*Cynorhaestes. Crotonus.* A genus of ticks, *Ixodinæ,* without eyes; with long palpi hollowed on the internal surface; tarsi without terminal spurs; pre-anal groove open posteriorly. *I. ricinus* is the castor-oil tick and is found on man, sheep, goats, horses, cattle, dogs, cats, rabbits, bats, birds, etc.; it carries *Babesia bigemina,* the cause of Texas fever. See *Arachnida.* A. S. P.

Ixodidæ.—A family of ticks which includes most of the known species. There is a dorsal scutum and a terminal capitulum; the digit of the mandible has two apophyses; the palpi are free. There are two sub-families: (1) *Rhipicephalinæ* in which the palpi are not longer than broad and the anterior portion of the body is emarginate, and (2) *Ixodinæ,* with palpi longer than broad, rostrum long, anterior portion of body straight or emarginate. See *Arachnida.* A. S. P.

Ixodinæ.—A subfamily of ticks in which the palpi are longer than broad; rostrum long; anterior portion of body straight or emarginate. The genera included are: *Ixodes, Euixodes, Eschatocephalus, Ceratixodes, Aponomma, Amblyomma,* and *Hyalomma.* See *Arachnida.* A. S. P.

Ixodoidea.—The order of Arthropods which includes the ticks. These animals are of importance in medicine not only on account of their unpleasant bites, but also because they spread diseases—Texas fever, African tick fever, Tsutsugamushi disease, spotted or mountain fever, etc. They are parasitic on mammals, birds, and reptiles, but are not strictly confined to one host. There are two families, the *Argasidæ,* chiefly on birds, and the *Ixodidæ,* or true ticks. See *Arachnida.* A. S. P.

Jaborandi.—See *Pilocarpus.*

Jaboulay, Mathieu.—One of the most brilliant surgeons of the Lyons school was born at Saint-Genis-Laval, July 3, 1860, and received his medical education at the Faculté de Médecine of Lyons. In 1881 he was appointed hospital interne and in 1886 was made head of the department of anatomy at the university. Ten years later he was appointed surgeon to the hospitals and in 1902 became professor of clinical surgery at the university in succession to Ollier, lately deceased. He was killed in a railway accident on November 4, 1913.

Jaboulay was a man of great learning and originality, a most skilful surgeon, and a successful teacher. Among the subjects of his special study were exothyropexy for goiter, division of the sympathetic for exophthalmic goiter, vascular anastomosis, incontinence of urine, perforating lesions of the gastro-enteric tract, and cancer. Among the most important of his writings were a collection of papers on "Surgery of the Great Sympathetic and Thyroid Body" (1900) and Surgery of the Nervous Centers, Viscera, and Limbs (1902); worthy of special mention also were articles on the "Microbe of Acute Osteomyelitis" (1885) and "Relations of the Optic Nerves with the Central Nervous Systems." T. L. S.

Jaccoud, Sigismond.—Born at Geneva, Switzerland, November 29, 1830, of poor parents, he was early thrown on his own resources, and supported himself during his medical studies by playing the violin in an orchestra of one of the Paris theaters and giving lessons on this instrument of which he was an accomplished master. He received an appointment as hospital intern in 1859 and obtained his doctorate from the Paris Faculty in 1860, his graduation thesis being on the pathogenesis of albuminuria. In 1862 he won through competitive examination an appointment as physician to the hospitals and became a professor agrégé in the Faculté de Médecine in 1863 and full professor in 1876. He died in April, 1913.

Jaccoud was a man of profound erudition, a diligent student gifted with a remarkable memory, and an acute observer. Among his notable contributions to medical literature were: "Paralysie et l'ataxie du mouvement" (1864), Leçons cliniques de la Charité" (1863), "Traité de pathologie interne" (1871), "Leçons cliniques de Lariboisière" (1873), and the great "Dictionnaire de médecine et de chirurgie" (1879–1886). T. L. S.

Jackson, James.—Born in Newburyport, Mass., on October 3, 1777. He was graduated from Harvard University in 1796, and received his medical degree from the same University in 1809. In 1812 he was appointed Professor of the Theory and Practice of Medicine in the Medical School of Harvard University, which position he held for twenty-four years. In 1817 he began service as First Physician of the Massachusetts General Hospital, in which capacity he served until 1837. He was elected President of the Massachusetts Medical Society for several successive terms. He died on August 27, 1867.

Among his most important writings are his "Letters to a Young Physician," which were written to his son, then just entering upon the practice of medicine. E. L. J.

Jackson, Robert.—Native of Stockton, County of Durham, England. He was employed for many years (during the latter part of the eighteenth century) as a surgeon in the British Army, much of his time being spent in the West Indies. In this way he gained considerable experience in the treatment of those maladies to which Europeans are liable during a residence in hot climates; and, in fact, for many years after his first book on tropical diseases was published, no other writer appears to have furnished equally valuable information. As long ago as 1808 he wrote a treatise on the employment of affusions of cold water on the surface of the body in the treatment of fever—a practice which was destined to be revived with great success by the Germans sixty or seventy years later. The following are the titles of a few of his more important published writings: "A Treatise

on the Fevers of Jamaica, with some Observations on the intermittent Fevers of America; and an Appendix containing some Hints on the Means of Preserving the Health of Soldiers in Hot Climates," London, 1791; "An Exposition of the Practice of Affusing Cold Water on the Surface of the Body for the Cure of Fever; to which are added Remarks on the Effects of Cold Drink and of Gestation in the Open Air, in certain Conditions of Disease," Edinburgh, 1808; and "Sketch of the History and Cure of Contagious Fevers," London, 1819. A. H. B.

Jacksonville.—The city of Jacksonville, the largest in Florida, is situated about twenty-five miles from the mouth of the St. John's River, on its left bank. It contains 57,699 inhabitants, which are largely added to during the winter months by transient visitors and invalids seeking a mild and salubrious climate. The city is well laid out with wide and well-shaded streets and parks, and offers all the advantages to be expected from a city of this size: good public schools, a library, opera house, public halls, and churches of various denominations. There is a good water supply from artesian wells, and a system of sewerage introduced under the direction of the late Colonel Waring. The death rate is low. There are good shell roads leading out of the city which afford good driving, automobiling, and cycling. The various excursions on the river are also attractive.

If one desires to spend the winter in a city in a mild and sunny climate, Jacksonville offers many advantages. There are excellent and abundant accommodations of all kinds, from the hotel of 500 guests to a variety of smaller boarding- and lodging-houses. Unfurnished cottages can also be obtained. The winter climate is mild and equable, and of medium moisture.

The following table gives the climatic data for the five winter months—November to March inclusive.

Climate of Jacksonville, Fla. Latitude, 30° 20′; Longitude, 81° 39′. Period of Observation, Twelve Years.

	November.	December.	January.	February	March	Year.
Temperature—						
Average or normal..	61.7°	55.8°	55.8°	58.1°	62.7°	69.2°
Average daily range	15.6	17.0	16.7	16.4	17.4	
Mean of warmest...	70.9	66.4	64.9	68.5	73.6	
Mean of coldest . .	55.3	49 4	48.2	52.1	56.2	
Highest or maximum	84.0	81.0	80.0	83.0	88.0	
Lowest or minimum	30.0	19.0	24 0	32.0	31.0	
Humidity—						
Average relative....	74.8%	73 7%	74 6	70 6	65 4	72 0
Precipitation						
Average in inches....	2.95	2.89	3.28	3 45	3.13	54.68
Wind—						
Prevailing direction	N. E	N. E.	N. E.	N. E.	S. W.	N. E.
Average hourly velocity in miles.....	6.5	6.0	5.8	6.9	7.9	6.7
Weather—						
Average number clear days.....	9.8	10.2	9.0	9 7	12.7	123.2
Average number fair days.....	11.1	12.0	12.8	10.4	13.0	156 7
Average number clear and fair days	20.9	22.2	21.8	20.1	25.7	279.9

Edward O. Otis.

Jacobi, Mary Putnam.—Born in London, August 31, 1842. She came to New York, and in 1861 entered the Woman's Medical College of Pennsylvania, at Philadelphia. Before undertaking the study of medicine she had received her degree as Doctor of Pharmacy in New York. After her graduation in medicine she served for one year as interne in the New England Hospital for Women and Children at Boston, and practised for two years in New York City. In 1866 she went to Paris and became a pupil at the Ecole de Médecine, being the first woman ever admitted to this school. She was, however, not the first woman graduate, as Dr. Elizabeth Garrett Anderson of London, who entered the same school later but took a shorter course, was graduated in 1870. Dr. Putnam was graduated in 1871, receiving second prize for her thesis. She returned to New York where she again began to practise and in time became one of the most famous and best beloved women physicians in the United States. She was the first woman to become a member of the New York Academy of Medicine and the first woman ever sent as a delegate to the Medical Society of the State of New York. She became a professor in the Woman's Medical College of the New York Infirmary, which post she held for ten years. Later she was appointed professor in the New York Post-Graduate Medical School and Hospital; physician to the Out-Patient Department of the Mt. Sinai Hospital, and Attending Physician at St. Mark's Hospital. In 1873 she was married to Dr. Abraham Jacobi of New York City. In 1874 she founded and was elected first president of the Association for the Advancement of the Medical Education of Women. In 1894 she became an ardent supporter of the ballot for women and delivered a memorable speech on this subject at Albany, N. Y. She died in New York on June 10, 1906.

Dr. Jacobi's contributions to medical and general literature were many and varied. During her years of study in Paris she was a regular correspondent of the *Medical Record*. In 1876 she won the Boylston prize at Harvard for an essay entitled "The Question of Rest for Women During Menstruation." She wrote the medical chapter in "Woman's Work in America," published in 1891, and was a contributor to the first edition of this Handbook. Her writings cover a list of over forty titles published in the various periodicals and encyclopedic text-books. "The Value of Life" was written by her in answer to Mallock's article "Is Life Worth Living?" E. L. J.

Jacobson, Julius.—Born in Koenigsberg, Prussia, on Aug. 18, 1828. He received his doctor's degree in 1853, from the University of his native city. In 1854 he visited Berlin for the purpose of perfecting himself as an ophthalmologist, and with this object in view he followed the teaching of Albrecht von Græfe. Thus was begun a friendship which terminated only with the latter's death. He settled in his native city as an eye specialist, and also to some extent as a general practitioner. In 1861 he was elected Professor Extraordinary, and soon afterward he began in earnest a struggle to obtain for ophthalmology an absolutely independent position in the universities of the Kingdom of Prussia—a struggle which he kept up without remission until the victory was finally won in 1869. In 1873 he was elected full Professor of Ophthalmology, and in 1877 he had the satisfaction of inaugurating in Koenigsberg the newly constructed and admirably equipped University Clinic for Eye Diseases. He died on Sept. 14, 1889.

Jacobson deserves great credit for having won for ophthalmology the independent position in the University curriculum which this specialty has now enjoyed in Prussia for over forty years. He is also to be remembered for the important contributions which he made to our knowledge of glaucoma and to the technique of the operation for the cure of cataract. His first paper on the latter subject was published in 1863 and is entitled: "Ein neues und gefahrloses Operations-verfahren zur Heilung des grauen Staares;"

and the second one appeared in 1888, under the title: "Extraction mit der Kapsel." Finally, ophthalmology is indebted to him for having discovered the surgical method of treating trachoma and for having developed the operation for trichiasis.

Of Jacobson's other contributions to medical literature we may here mention only the following: "Albrecht von Graefe's Verdienste um die neuere Ophthalmologie," 1885; "Beziehungen der Veränderungen und Krankheiten des Seehorgans zu Allgemeinleiden und Organerkrankungen," 1885; and "Beiträge zur Pathologie des Auges," 1888.

A. H. B.

von Jaeger, Eduard.—Born in Vienna, Austria in 1818. At an early period of his career he devoted himself to the study of ophthalmology. In 1854 he was made a *Dozent* of this department of medical science in the University of his native city, and somewhat later he was given permission to conduct a private clinic for eye diseases in the Allgemeines Krankenhaus; the faculty permitting him at the same time to use the title of "Professor." It was only in 1883, after his famous contemporary, von Arlt, had resigned his position in the faculty, that von Jaeger was made a full Professor of Ophthalmology. He died July 5, 1884.

von Jaeger, according to Pagel (Biographisches Lexikon), made several valuable contributions to the science of ophthalmology. The most brilliant of these relate to the history of ophthalmoscopy, von Jaeger having devoted the greater part of his lifetime to the development of this new method of investigating the eye. It was he, for example, who first demonstrated how the ophthalmoscope, as intimated by Helmholtz, may be used in everyday practice in determining the exact state of the refraction of the eye. Finally, he deserves special credit for having given to the profession a very practical collection of tests for determining the acuteness of vision.

A. H. B.

Jalap.—The tuberous root of *Exogonium purga* (Wend.) Benth. (*Ipomœa F.* Hayne; I, *Jalapa* Schiede and Deppes—fam. *Convolvulaceæ*, yielding, when assayed by the U. S. P. process, not less than eight per cent. of total resin.

This is a perennial, herbaceous twiner with numerous slender, twisted and furrowed, moderately branched stems, arising from ovoid, pear-shaped, or subspherical tubers, these often clustered or tangled together by roots and rhizomes. The flower is merely a large, handsome, rose-colored "morning glory." It is a native of Eastern and Central Mexico, from one town of which it has received its name (Jalapa). Jalap was known and brought to Europe as early as the beginning of the sixteenth century, if not before. Its botanical source was demonstrated first in the early part of this century, by Dr. Coxe, of Philadelphia.

The collection of jalap is carried on without much regard to season. The tubercles are dug up and dried by artificial heat, the smaller ones entire, the larger scored (usually lengthwise), or split or sliced. The heat employed is often sufficient to break the starch granules, and so, when dry, the texture is often horny, on account of the hardened starch mucilage, irrespectively of the amount of resin contained. The cultivation of jalap is in its infancy.

Description.—The jalap tubercles are in part described above; the Pharmacopœial description is as follows: "Napiform, pyriform, or oblong, varying in size; the larger roots incised, more or less wrinkled, dark brown, with lighter-colored spots, and short, transverse ridges; hard, compact, internally pale grayish-brown, with numerous concentric circles composed of small resin cells; fracture resinous, not fibrous; odor slight, but peculiar, smoky and sweetish; taste sweetish and acrid.

"On exhausting 100 parts of jalap with alcohol, concentrating the tincture to forty parts, and pouring it into water, a precipitate of resin should be obtained, which, when washed with water and dried, should weigh not less than 8 parts, not over 1½ of them soluble in ether."

Cultivation is an important factor, as under it twenty per cent. of resin has been produced. The dried tubercles of the market have shrunken and shriveled considerably, and are usually much more acute than represented in the above cut of living roots.

Composition.—Jalap contains a large amount of sugar and of starch, substances which contribute to its taste and texture, but have no further value. Its active principle is a composite *resin*, the quantity of which determines the value of the article. This crude substance consists of two resins, both of which are soluble in alcohol, but only one of which (the less considerable) is also soluble in ether; the insoluble portion is called *convolvulin*. It is regarded as a glucoside. Merck gives the formula as $C_{31}H_{50}O_{16}$ and the dose as gr. i.–iij. It is only partly soluble in water. It is converted by alkalies into convolvulinic acid, which is active in three times the dose of the convolvulin. The jalapin is also active, and is the principal constituent of scammony. The crude resin of jalap is official (*Resina Jalapæ*, U. S. P.), and in common use.

Action and Use.—Jalap is one of a considerable number of active cathartics whose energy either lies in their resinous contents or is at present inseparable from them. Of these, however, it is one of the mildest and most uniform, and probably, in consequence, one of the most frequently employed. In full doses it produces free hydragogue catharsis, with more or less, but generally not excessive, nausea and griping.

It has been traditionally used as an adjuvant to calomel. Of its action upon other organs than the stomach and bowels but little can be said. It is doubtful whether much of it is absorbed. It will not act if injected hypodermically.

Administration.—Powdered jalap is frequently given, and contains so little woody tissue that it is a very good form. Dose, gr. xv.–xx. (1.0–1.3); as a drastic purgative sometimes twice as much. The resin is about five or six times as active as the crude powder. The compound powder of jalap (Pulvis Jalapæ Compositus) is frequently of use in anasarca, when a combined effect upon the kidneys and intestines is desired. It consists of jalap, thirty-five parts, and cream of tartar, sixty-five. Dose, a gram or so twice a day. There is also an official alcoholic extract, the dose of which is gr. ij.–viij (0.12–0.5).

Henry H. Rusby.

Jamaica.—Jamaica, a British colony, is an island in the Caribbean Sea, lying between 17° 43′ and 18° 32′ North Latitude, and 76° 11′ and 78° 20′ 50″ West Longitude. It is about ninety miles south of Cuba, nearly 5,000 miles from Southampton, and a little more than 1,400 miles from New York. It is 144 miles in length and from twenty-one and a half to forty-nine miles in width and has an area of 7,207 square miles. The surface of the island is crumpled up into a central mountain range with numerous outlying spurs. The highest points of this range, contrary to the rule, are in the eastern portion, whence the surface slopes irregularly toward the west, where the only level parts of any extent are found. There is one principal range, called the Blue Mountains, running east and west through the center of the island, and from this secondary ridges run north and

south, themselves giving off other and shorter spurs in a direction parallel to the central range. The highest point is Blue Mountain Peak which rises to an elevation of 7,360 feet; Catherine's Peak has an altitude of over 5,000 feet; and there are several others, varying in height from 4,000 to 5,000 feet. The island is in general well watered, the abundance of rivers and springs in most parts giving plausibility to the generally accepted interpretation of the name, Jamaica, which is believed to have signified in the aboriginal tongue the "Isle of Springs," or the "Land of Wood and Water."

It is difficult, in a brief article of this nature, to describe satisfactorily the climate of Jamaica, as, owing to the diversity of elevation and other causes, it varies greatly in different parts of the island; in some parts it is hot, in others temperate and even cool; in some it is dry, in others the rainfall is very great; and indeed the only characteristic common to all the varying climates of Jamaica is equability. Thus, at the sea-coast the average temperature is 78° F. (the extreme range for the entire year being only 35° F.), while on the mountains at an elevation of between 4,000 and 7,000 feet the mercury ranges from 40° to 74° F., occasionally falling, on the summit of the highest peak and in midwinter, even to the freezing-point.

Meteorological Data for Points of Different Elevation in the Island of Jamaica for 1899.*

Hope Garden, Elevation 600 Feet.

Months	Mean average temperature.	Maximum temperature.	Minimum temperature	Range.	Humidity	Rainfall in inches
January..	71 4°	85.0°	65.4°	19.6	81.5%	1.47
February.....	...	...	...	...	...	...
March	71.9	83.3	65.7	17.6	68.5	1 49
April.....	76.5	84.2	66.2	18.0	68.5	2.75
May.....	78.1	87.5	66.9	20.6	70.5	5.23
June.....	79.6	89.6	71 1	18.5	71.0	1.99
July.....	80.9	91.8	69.7	22.1	65.5	2.82
August.....	81.3	91.3	69 6	21 7	67.5	1.39
September.....	79.2	89.2	70.5	18.7	77.0	5.37
October.....	76.7	85.5	69.3	16.2	82.5	31 73
November.. ..	76.2	85.3	68 2	17.1	83.5	16.93
December.. .	73.2	83.9	63.9	20.0	78.0	10.06

Stony Hill Reformatory, Elevation 1,400 Feet.

Months.	Mean average temperature.	Maximum temperature.	Minimum temperature	Range	Humidity	Rainfall in inches.
January.... .	71.8°	81.3°	63.4°	17.9	89.5%	1.47
February.....	72.0	82.9	63.0	19.9		0.55
March.....	72.4	81.2	64.4	16.8	83.5	2.36
April.....	72.5	82.6	63.4	19.2	90.5	3.79.
May.....	75.8	85.2	64.3	20 9	88.5	5.79
June.....	75.9	86.8	66 0	20 8	83.0	3.93
July..... ..	77.8	87.6	67.6	20.0	76.0	5.21
August.....	78.0	88.3	67.7	20.6	81.0	1.64
September.....	76.8	87.1	67.5	19.6	79.5	9.99
October.....	74.8	84.0	66.5	17.5	81.0	34 93
November..... ..	73.4	84.9	65.6	19.3	73.0	19.41
December.. .	71.4	82.1	61.8	20.3	84.0	9.23

Mandeville, Elevation 2,100 Feet.

Months	Year	Maximum temperature	Minimum temperature	Range	Days above 80°.
December.	1900	81.7°	65 3°	16.4	6
January..	1900	81.0	61.4	19 6	1
February		81.1	60.2	20 9	3
March		80 6	61.7	18.9	4
April		85.7	60.0	25.7	11
May.....		81.7	64 3	17.4	5
June		81.0	67.8	13.2	1
July		81 8	68.0	13.8	6
August....		82.7	67.2	15 5	12

Hill Gardens, 4,907 Feet.

Months	Mean average temperature	Maximum temperature	Minimum temperature	Range.	Humidity	Rainfall in inches
January...	60 3°	67.4°	54 3°	13 1 86 0%		14 54
February..	60 6	67.7	53.9	13.8 84.0		1 04
March .	69 4	65.6	53.5	12.1 85.5		5.16
April .. .	61 3	66.6	55.1	11.5 84.5		4.21
May..... .	63 5	69.2	56 6	12 6 81.0		4.54
June	64 9	70.4	58.4	12.0 82.5		1.78
July . . .	65 0	70.8	57.5	13.3 79.5		2.32
August.... .	64 8	74.2	57.5	16 7 79.5		0 76
September	65 4	72.5	59.8	12.7 85.0		5.39
October...	63 0	68 0	58.6	9.4 89.5		41.22
November.	62 7	67 7	58 0	9.7 88.5		44.09
December.	60 5	66.5	54.4	12.1 83.5		16 90

Blue Mountain Peak, 7,423 Feet High.

Time of observation.	Temperature	Maximum	Minimum.	Rainfall since last observation
February 1st, 11:30 A.M.	56°	69.9°	38.8°	24.87
March 1st. .	56	68.9	39.8	4.15
April 1st, 11:30 A.M.....	58	64.9	40.8	8.10
June 1st, 10:30 A.M.....	65	69.9	44.8	8.23
June 30th, 11:15 A.M.	58	70 9	46.8	5 45
July 31st, 11 A.M. .	59	71.9	46.8	6.05
August 31st, 10 A.M.	67	74.9	44.8	6.45
October 2d, 1 P.M.	59	73.9	43 8	12.90
November 1st, noon.....	56	70.9	42.8	15.95
November 30th, 11:30 A.M	69	70.9	46.8	48.16
December 31st, 11:45 A.M..	67	71.9	41.8	25.45

The most striking peculiarity of the climate of Jamaica is its variety combined with equability. A ride of a few miles into the hills will bring one from the torrid zone to the temperate—from an average temperature of nearly 80° F. to one of 65° or 70° F. But whatever district one may select, whether a warm or a cool one, he will find the temperature very nearly constant, the extreme range for any one month being seldom over 25° F., while that for the entire year at Kingston is but 35° F., and in some parts of the island the excursions of the mercury are even more restricted than this. The humidity in every part of the island is comparatively high, but varies considerably in different localities. Jamaica, indeed, enjoys all the advantages, in respect to uniformity of temperature, of island climates in general, while the differences in elevation and in exposure to, or protection from, the prevailing trade winds give to it the pleasing diversity, as regards temperature, humidity, and rainfall, of the most temperate of continental climates.

There is, as a rule, less rain in Kingston than in most of the other parts of the island, the trade winds being

* Through the kindness of Prof. W. H. Pickering, of the Harvard College Observatory, I have obtained the Jamaica weather report for 1899 from which the following meteorological data have been compiled for points of various elevation in the island; and to this are also added the maximum and minimum temperatures of Mandeville, observed by Professor Pickering during his nine months' residence there.—E. O. O.

drained of their moisture by the mountains to the north and east of the city. The heaviest precipitation occurs in the Parish of Portland, which forms the northeastern extremity of the island. There are two principal rainy seasons, namely, in May and October, but there is usually more or less rain all through the summer months; in the winter season in the neighborhood of Kingston the precipitation is very light. The rain usually comes in heavy showers of only a few hours' duration, and the days during which the sun does not shine at all are very rare. It is always possible to tell when rain is coming, as it can be seen, quite a while before its arrival, advancing from the mountains, thus giving one ample time to get under cover before the downpour begins. This is fortunate for the visitor, as a wetting is one of the three things that an unacclimated person in the tropics must avoid, the other two being exposure to the direct rays of the noon-day sun and to the cool night air. The annual average rainfall for the island is 66.3 inches, and for Kingston 32.6 inches. In some places in the northeast it exceeds 200 inches.

The population of Jamaica is estimated at 806,690. The capital and chief city is Kingston, the largest and most important as well as the healthiest seaport town of the British West Indies. It is a city of 50,000 or more inhabitants, situated on gently sloping ground on the shores of a large land-locked harbor. The land on which the city lies is a gravel bed, and as it has a slope to the sea of about ninety feet to the mile the natural drainage is excellent. The water supply is drawn from two rivers at a distance of several miles from the city, and, as regards freedom from contamination, is above reproach. In 1907 Jamaica was visited by an earthquake which greatly damaged Kingston, and in 1903 by a hurricane, the first destructive one in 200 years.

The Myrtle Bank Hotel, pleasantly situated on the shore of the bay near the outskirts of the city, affords excellent accommodation for visitors, and there are also several other hotels and a number of boarding-houses where one may live modestly and at moderate expense. Another well-built hotel, having accommodation for 150 to 200 guests, is at Constant Spring, six miles from Kingston, near the foot of the mountains which enclose in the form of an amphitheater the Liguanea plain. The hotel lies at an elevation of 500 feet above Kingston, and from it is had a fine view of the harbor and Caribbean Sea beyond. The temperature here is uniformly ten to twelve degrees lower than that of the city. Other comfortable hotels are found in Santiago de la Vega, usually called Spanish Town, which was formerly the capital of the island, and at Moneague, a charming spot in the Parish of St. Ann, on the northern slope of the central mountain range. Mandeville, a beautiful little place in the hills, celebrated for its delicious oranges, is a favorite resort for Jamaicans from Kingston and other coast towns who may feel the want of a change of air and scene. There are a hotel and several boarding-houses here, but intending visitors must take the precaution to apply in advance if they would be sure of being well suited. Among the coast towns on the north side of the island, Lucea, St. Ann's Bay, and Montego Bay are the most important from the point of view of the tourist and the invalid. In these and the other towns of the island visitors may find accommodation at various boarding- and lodging-houses about which, however, it would be wise to inquire before making a selection, as they are of varying degrees of excellence and the reverse. At Port Antonio the headquarters on the island of the United Fruit Co., is an excellent hotel, the "Tichfield."

At Port Henderson, on the southern shore of the island, at the entrance to Kingston harbor, there is a saline-calcic spring which is said to possess tonic properties of no mean order and is much resorted to as a bath by convalescents and others from the neighboring districts. There is also a good beach for sea-bathing. There are several buildings here in good order, but the accommodations are not extensive. The place can readily be reached, however, by a steam launch from Kingston in forty-five minutes. No analysis of the water of the spring has ever been published.

The diseases for the climatic treatment of which Jamaica is well suited are bronchitis, catarrhal affections of the respiratory passages, Bright's disease, rheumatism, various forms of dyspepsia, and nervous prostration. All parts of the island are naturally not suitable for the treatment of all these affections, but for each one a locality exists where the patient can find the climate especially adapted to the necessities of his particular disease. Respiratory affections especially do well in this mild and equable climate, as may be judged from the records of one of the life insurance companies doing business on the island, which show that the company lost but one life from diseases of the respiratory organs (bronchitis) during a period of thirty-five years. Patients suffering from these troubles are relieved in almost any part of the island, although there is even here a choice, as cases with scanty expectoration are most benefited in those districts where the atmosphere is most laden with moisture, while those in which there is free or even profuse secretion are more quickly relieved in the neighborhood of Kingston and other parts where the humidity of the air is at a minimum. Patients with nervous prostration receive more benefit from a stay near the seashore than they do in the uplands, and the same is in a measure true of dyspeptics, especially of those in whom the gastric trouble is partly nervous in its origin. Sufferers from Bright's disease do well, as a rule, in all parts of the island, except possibly in the most elevated regions, where in the winter months the thermometer is apt to fall a little too low after the sun goes down, and where, especially on the northern slope, there is at times rather too much rain to be agreeable. The same remarks apply also in the case of rheumatic patients, but the latter would do well to take a course of the waters at one of the numerous mineral springs, of which a few words may be said in closing this article. The climate of the Santa Cruz mountains is said to be favorable for those suffering from tubercular and rheumatic affections.

There are several medicinal springs in Jamaica, some thermal and others cold, which possess therapeutic properties of no little value, and which are deserving of more careful study by balneologists than they have hitherto received. The most important of these, or at least the best known and the only ones at which passable accommodations for visitors are as yet provided, are the Bath of St. Thomas the Apostle, about a mile from the town of Bath, in the Parish of St. Thomas, the Jamaica Spa, at Silver Hill, in St. Andrew's Parish, and the Milk River Bath at Vere, in the Parish of Clarendon. The first of these is a thermal sulphur, the second a chalybeate, and the third a thermal saline water. All of these springs are quite easily accessible from Kingston.

The limits of this article will not permit of a detailed description of each of these springs. The waters of one or the other of them are of value, taken internally and applied in the form of baths, in the treatment of gout, rheumatism, chronic bronchitis, catarrhal conditions of the stomach and intestines, constipation from abdominal plethora, hepatic and other congestions of the abdominal viscera, amenorrhea, anemia and chlorosis, various forms of skin diseases, tertiary syphilitic lesions, and chronic malarial affections. The Government has made grants from time to time for the improvement and care of the buildings at these baths, but there is yet much to be desired in the matter of cuisine, bathing facilities, attendance, and other things that contribute to the comfort and entertainment of the invalid. In the absence of these

desiderata they still possess the great advantage that they may be visited in the winter season, when the more pretentious and better equipped spas in Europe and the United States are closed. The island is generally healthy and yellow fever is a rare occurrence.

There are several lines of steamers running between Jamaica and New York, Boston, Philadelphia, Baltimore, Newport News, and Halifax, the voyage from New York being made in from four to six days. The steamers of the United Fruit Company running from Boston, New York, and Philadelphia have excellent accommodations.

There is usually no lack of amusements in Kingston in the way of horse races, yachting, tennis and cricket matches, etc., and there is also a theatre where performances and concerts are given occasionally during the winter. The roads throughout the island are up to the best English standard and the facilities for riding and driving and motoring are unsurpassed. A railroad runs from Kingston in a northwesterly direction to Montego Bay, with a branch line to Anatto Bay and Port Antonio, towns on the north shore, and a spur to Ewarton. Communication with the coast towns is had also by steamers which sail around the island once a week, leaving Kingston every Tuesday. There is frequent mail communication with the United States and Canada, and the island is also connected with this country by cable. Churches of all the leading denominations are found nearly everywhere, and in most of the larger towns are well-appointed clubs, libraries, and social organizations of various sorts.

The best months in which to visit Jamaica are November to April inclusive, as these are the coolest and dryest of the year, but one accustomed to the fierce summer heats of our Northern cities would find a grateful change in the hills of Jamaica even in midsummer.

Much valuable information concerning Jamaica as a health resort may be obtained from a work on "The Climate of Jamaica," by the Hon. J. C. Philippo, M. D., published by T. & A. Churchill, London; from "The Handbook of Jamaica," published annually in London and Kingston, and from various good guide books recently published.

Jamaica is one of the most beautiful islands of the West Indies as to both the variety and charm of its scenery and the luxuriance of its vegetation; oranges, coffee, the cocoanut, bananas, sugar-cane, and a variety of other tropical fruits grow luxuriantly here. The cultivation and exportation of bananas is now a great industry. The roads, as has been noted above, are hard and white and kept in good repair by the Government, so that one can traverse the island comfortably either by carriage, or automobile. Whether one skirts the shore with its irregular windings, or seeks the mountainous region of the interior, he will meet not only with a greater variety of climate than is found in any other of the West India islands but an infinite variety of attractive scenery. The excellence of the steamers of the United Fruit Company and their swiftness have made an excursion to this island very popular during the winter and spring months. The usual passage from New York or Boston occupies from four to five days.

THOMAS LATHROP STEDMAN.
Revised by EDWARD O. OTIS.

Jambul.—This is the local name applied to the bark and seeds of *Eugenia Jambolana* Lamarck, a tree belonging to the natural order Myrtaceæ. It is indigenous to tropical Asia and the neighboring islands, where it grows to a large size and bears a crop of edible fruit. It was brought to the notice of English physicians in India in 1883 as a remedy for diabetes and for several years was extensively employed. Numerous favorable reports of its use were published, but it has fallen into disuse and its employment is now obsolete. It is highly esteemed in India, by the native physicians as a valuable remedy in stomach and intestinal diseases. BEAUMONT SMALL.

Janeway, Edward Gamaliel.—Born in Middlesex County, New Jersey, on Aug. 21, 1841. He studied medicine at the College of Physicians and Surgeons, New York City, and received his doctor's degree from that institution in 1864. In 1866 he was appointed Curator to Bellevue Hospital, a position which he held until 1872, when he was made a Visiting Physician to the hospital. In the latter year he was appointed Professor of Pathological Anatomy in

FIG. 3552.—Edward Gamaliel Janeway.

Bellevue Hospital Medical College, and, in addition, Lecturer on Materia Medica, Therapeutics, and Clinical Medicine. In 1881 he became Professor of Diseases of the Mind and Nervous System in the same school. In 1886, upon the death of Dr. Austin Flint, Sr., he succeeded him as Professor of the Principles and Practice of Medicine and Clinical Medicine. After the University and Bellevue Hospital Medical Colleges had been united, he continued to hold this position up to the time of his resignation in 1907. From 1875 to 1881 he was a Commissioner in the Health Department of New York City, and in 1892, when the city was threatened with an invasion of Asiatic cholera, he was a member of the Advisory Committee of the New York Chamber of Commerce. He died Feb. 10, 1911.

Dr. Janeway was exceptionally well equipped for the attainment of the best kind of professional success. To begin with, he was pre-eminently truthful, and whatever he undertook he carried out in a serious and persistent manner, thus conveying the impression that he was a man to be trusted in great responsibilities To these fundamental characteristics there should be added the facts that the best of opportunities for gaining a thorough knowledge of the diseases which afflict the human body were placed within his grasp, and that he knew well how to make the most of these opportunities. Thus, in time, he came to be one of the very best diagnosticians in New York, and withal a therapeutist of excellent efficiency. The great popularity which he eventually gained among his professional brethren, and which made him one of the leading consultants, not merely in the city in which he resided, but also throughout a wide outlying territory, could not have been acquired if he had not possessed two other very important mental characteristics—a judicial type of mind and a courteous manner of dealing with those whose opinions differed from his. A. H. B.

Janin, Jean.—Born at Carcasonne, France, June 12, 1731. His medical studies were prosecuted at Montpellier, and he settled at Colmette, near Nîmes. He soon acquired a lucrative practice; but, feeling the need of broadening his knowledge of medicine, he resumed his studies at Avignon. It was at this time (between 1740 and 1750) that he first began to take a special interest in diseases of the eyes, and it was not a long time before he had the opportunity to operate for cataract upon an ecclesiastic who had come from Lyons to consult him. The operation proved to be an entire success, and from that time public attention was riveted upon him as an eye surgeon. Other people living in Lyons sent for him, and he was again successful in his operations upon these new patients. Being urged to settle in that city, he decided that he would take this step, but not until after he had passed a certain length of time in Paris under the instruction of the best specialists in that metropolis. From 1767 to the time of his death (in 1799) Janin lived in Lyons. In 1787 he received a title of nobility, under the name of "Combe Blanche."

The Dictionnaire Historique de la Médecine ranks Janin as one of the most distinguished oculists of the eighteenth century. Probably the most important one of his published writings is that entitled: "Mémoires et observations anatomiques, physiologiques et physiques sur l'œil et sur les maladies qui affectent cet organe, avec un précis des opérations et des remèdes qu'on doit pratiquer pour les guérir," Lyon et Paris, 1772. A. H. B.

Japanese River Fever.—*Synonyms:* Tsutsugamushi; Shima Island Disease; Kedani (hair-louse) Disease; Aka mushi (red insect) Disease; Tochu-bio and Shasitsu in different localities.

Japanese river fever is an acute, febrile, endemic disease produced by the bite of a red mite (harvest mite), *Trombidium akamushi* Brumpt 1910 which becomes very numerous about July following the overflow of certain rivers in the Island of Nippon, in Japan.

The history of the disease dates back at least a thousand years when it was described in Chinese writings under the name of "Shashitsu" according to Ashburn and Craig. The Chinese thought it to be due to the bite of an insect which attacked certain persons who entered certain regions after an overflow during the summer. These authors give an excellent account of the disease in 1908, with a comparison of it with Rocky Mountain Spotted Fever of the United States.

The distribution seems to be confined to certain regions only of the Akita district drained by the Omogawa and Minasegawa rivers; and the Nugata district, drained by the Shinanogawa, Akagawa, Uwonumagawa rivers. The mite, the bite of which causes the disease, is sometimes transported with corn, hemp, and other field crops and may be a source of infection occurring outside of the district in which it is endemic.

Etiology.—That the specific organism, either bacterial or more likely protozoan, which causes the disease, is inoculated into man by the bite of the larva of Trombidium seems to be established. The same species of mites in other regions are not capable of producing the infection. They may be found in large numbers on the inner surfaces of the ears of field mice in the infected district during the summer. These mice are said to be immune but this view is doubted by others. It is quite possible that they do possess a considerable degree of immunity which makes it possible for them to serve as host for the infectious agent.

Monkeys have been successfully inoculated by Miyajima with blood from a person suffering from the disease.

Ogata claims to have found a plasmodium in the blood of several patients, and that guinea-pigs and mice can be successfully inoculated. His work has not been confirmed and in fact Miyajima considers these animals immune.

Though it is much more prevalent among the poorer laboring class this is quite likely because only this class will go into the known infected districts. Some of these have practically been abandoned because of the great risk necessary to be taken by the laborers in harvesting the crops.

Symptoms.—The disease begins with a chill followed promptly by fever ranging from 103° F. to 105° F. in most instances. Sometimes it may run lower. This symptom is continuous for about fourteen days when it begins to remit considerably and goes off by lysis by the twenty-first day, in most cases. At the first there is severe frontal headache and complaint of weakness, but the pulse rate ranges between 80 and 100. Later it gets a little more rapid as the patient gets weaker. Most of the constitutional symptoms are those that accompany other acute infectious diseases of equal severity.

The patient complains early of pain in certain of his lymphatic glands, usually the axillary or inguinal. Upon examination they are found enlarged, tender, but movable. This is said to be true in contrast to the swelling of the periglandular tissues in bubonic plague. The lesion at the site of the bite, usually around the genitals or axillæ which is drained by the gland or glands involved is a vesicle two to four millimeters in diameter or more frequently at the time the patient is seen for the first time it consists of brown or black necrotic skin surrounded by dull red areola. There may be only one or several lesions. The necrotic skin is separated from the living tissue and thrown off in about two weeks, leaving a punched-out ulcer.

At the end of about the fifth day a macular eruption appears on the body more pronounced on the face and less marked on the arms and legs. The macules are two to five millimeters in diameter and sometimes become confluent. The eruption begins to fade in about a week; there is no noticeable desquamation.

Early in the disease there is increased flow of tears, and secretion from the nose, throat, and bronchi which later give rise to râles usually throughout the disease. Injection of the conjunctivæ is marked at the time of appearance of the eruption.

Hyperesthesia and photophobia are usually prominent symptoms. In the young and in those attacked for the second or third time the symptoms are much milder. In the mildest cases the local lesion accompanied by glandular enlargement may be accompanied by mild constitutional symptoms only and recovery occurs in a few days. In the severest cases death results usually during the second week from the hyperpyrexia, pulmonary complications or cardiac failure.

Prognosis.—The mortality is given as about thirty per cent. by Castellani and Chalmers, 1913, in an excellent description of the disease. It is much worse in the aged with their first attack.

Diagnosis.—The differential diagnosis is to be made between this disease and ordinary infected wounds accompanied by lymphadenitis and from bubonic plague. In most simple adenitis the primary lesion will usually be recognized and it is different from the lesion in the River Fever with its characteristic necrotic center. Gland puncture with microscopic examination of the juice for the characteristic bipolar staining, egg-shaped B. pestis, in plague is negative in this disease. It is to be differentiated from typhus by the characteristic lesion and the absence of petechial eruption.

Pathology.—Castellani and Chalmers, 1913, describe the pathology in addition to the local lesion as follows: "The spleen is enlarged and softened; the lung is edematous and congested and the bronchial mucosa is often slightly swollen and reddened and the kidneys are inflamed. We are not acquainted with any description of the histology of the organs."

Treatment.—There is no specific treatment though quinine is usually given. General measures as indicated are to be employed. The coal-tar preparations are said to be poorly borne.

Applications of oil of eucalyptus or balsam of Peru on arms and legs and in the groins and axillæ are thought to keep off the mites. C. C. Bass.

Jasmine, Yellow.—See *Gelsemium.*

Jaundice.—*Synonyms:* Icterus; Morbus regius. Jaundice is a syndrome and not a disease, a condition marked by increase of bile pigment in the blood serum and by staining of the skin, conjunctivæ, and urine. Gilbert has shown that the serum normally contains bile pigment, in the proportion of 1 to 36,000 according to his investigations; Hymans, Bergh, and Snapper (*Berlin klin. Woch.*, 1914, Nos. 24 and 25) have confirmed the bile content of normal serum but they place the threshold of elimination by the kidney at 1 in 60,000. Up to a certain concentration of bile pigment in the serum there is no staining of the tissues. Since the first formulation of theories of Frerichs and Kuehne there has been interminable discussion of what may be termed the pathological physiology of jaundice. The liver was long regarded as a separator rather than a producer of bile pigment; given a cause of blood destruction, bilirubin could be formed in the blood stream or in tissues; the hepatic cell might prove unequal to the demands of elimination or its function be suppressed and jaundice resulted. Of late years there has been practical unanimity in abandoning such a view, and the paramount importance of the liver cell in the manufacture of bile pigments has seemed unquestioned. The experiments of Kunde and Moleschott with cold-blooded animals, of Stern with pigeons, of Naunyn and Minkowski with geese and ducks seemed to show conclusively that it is the liver cell above all that is concerned in the elaboration of bilirubin from hemoglobin. The theory of hematogenous jaundice was practically abandoned and all jaundice was regarded as of liver origin.

It is true that small amounts of bilirubin may be found in other places than in the liver, pigment has been found in apoplectic foci, blood extravasations, and hemorrhagic infarcts in the form of hematoidin crystals which are indentical with bilirubin. Loewit, in frogs, showed that leucocytes could take up fragments of red cells and elaborate them in different tissues to granules of bile pigment. Naunyn and Minkowski, in the course of their experiments with hemolytic poisons in geese and ducks demonstrated leucocytes in the liver containing fragments of red corpuscles and granules of bile pigment. In hemorrhagic effusions bile pigment may be demonstrated in large amount and it may be formed in considerable quantities in experimental hemorrhagic lesions. Normally in dogs bile pigment is not found in the blood serum while it is present normally in considerable quantities in the serum of horses. Its presence physiologically in the serum of man is against the theory that icterus always arises from the activity of the liver cells and from bile stasis. The work of Whipple and Hooper (*Jour. Exper. Med.*, vol. xvii., p. 597) has raised further doubt of the present belief that all bile pigment is derived solely from the hemoglobin of the erythrocytes and that the transformation occurs only through agency of the liver cells. Their experiments have shown that there may be rapid change of hemoglobin to bile pigment in the circulation outside the liver, possibly by endothelial cells or by cells of bone marrow or muscles.

Practically, however, almost every icterus is an icterus from absorption of bile from the liver. It is possible under certain conditions that functionally disordered liver cells may allow passage of bile directly into the lymphatics or blood-vessels of the liver instead of into the bile capillaries. This is the so-called parapedesis of bile (Minkowski), diffusion icterus (Liebermeister), paracholia (E. Pick). It seems probable that the mechanism of absorption may be different in different cases of jaundice termed obstructive or mechanical or "ascending" jaundice. The liver cells are continuous with the walls of the bile capillaries, and Kuppfer has demonstrated prolongations of the capillaries even within the liver cell. With stasis in the small ducts the pressure of bile secretion (not more than 200 millimeters of water) is readily overcome and bile passes from the intercellular duct to the lymphatic vessels near the bile capillaries, thence to the large lymphatics, thoracic duct, and to the blood stream. It is possible under certain conditions that functionally disordered liver cells may send bile to the blood capillaries and not to the bile ducts, or may allow passage of bile from the ducts back to the blood-vessels and not to the lymphatics. Recent experiments have furnished proof of this passage of bile to the blood-vessels and shown that a fistula of the thoracic duct does not prevent jaundice.

The investigations of Charcot, Legg, Hunter, Banti, Eppinger, Stadelmann, and others have broadened our views of mechanical jaundice. Under the influence of increased hemolysis from toxic or infectious cause, excess of hemoglobin is brought to the liver and elaborated into bile. There is increase in quantity of bile, but particularly an increase in viscidity and pigments, a polycholia and particularly a pleiochromia. This thick, viscid bile leads to stasis in the small bile channels, to irritation and swelling of the mucosa, to obstruction and to icterus by absorption; again an icterus of obstruction, but a descending rather than an ascending icterus. Even without increased amount of viscidity of bile, the eliminated poisons in course of an intoxication or infection may lead to catarrh of the bile terminals, to swelling with mechanical blocking and absorption. Though all cases of jaundice may be classed as obstructive, the following classification somewhat modified from Hunter is a convenient one for descriptive purposes.

I. Obstructive Jaundice.—Causes acting from within or without the bile ducts. The obstruction is obviously mechanical and independent of changes in the blood or bile. The following is substantially the table of Murchison:

A. Obstruction by Foreign Bodies within the Duct.

1. Gallstones, inspissated bile, blood clot.
2. Foreign bodies from the intestines.
3. Parasites—hydatids, distomata, lumbricoids.

B. Obstruction by Catarrhal Swelling of Large or Small Ducts.

C. Obstruction by Stricture or Obliteration of Ducts.

1. Congenital deficiency or stricture of ducts.
2. Stricture from perihepatitis, from ulcer of the duodenum, from ulcers or scars in the bile ducts.
3. Spasmodic stricture (icterus psychicus).

D. Obstruction by Tumors at the Papilla or of the Bile Ducts.

Fibroma, lipoma, gumma, papilloma, xanthoma, sarcoma, carcinoma.

E. Obstruction by Pressure from without.

1. Tumors of the liver.
2. Tumors of the gall-bladder.
3. Enlarged glands in the fissure of the liver.
4. Tumors of the stomach or duodenum.
5. Tumors of the pancreas.

6. Tumors of the kidney.
7. Floating kidney.
8. Omental tumors.
9. Retroperitoneal tumors.
10. Aneurysms of abdominal aorta, hepatic artery.
11. Fecal tumors, especially of the hepatic flexure.
12. Pregnant uterus, tumors of the uterus.
13. Ovarian tumors.

II. Toxemic Jaundice.—Jaundice dependent on changes in the blood and bile; the end cause is obstruction dependent on increased viscidity of bile or on catarrhal swelling of the bile ducts. This is the group formerly called hematogenous. Hunter classifies causes as follows:

1. *Definite Poisons.*—Phosphorus, arsenic, tolylendiamin, snake venom, chloroform, chloral, benzol, anilin compounds.

2. *Poisons of Infectious Fevers.*—Yellow fever, malaria, pyemia, typhus, typhoid, relapsing fever, scarlatina, pneumonia.

3. *Special Icterogenic Poisons.*—These are of probable infective nature. Various names have been given to the jaundice, as epidemic, infectious, febrile, malignant, septic, Weil's disease, icterus typhosus, icterus gravis, acute yellow atrophy of the liver.

III. Hemolytic Icterus.—Under this heading may be grouped chronic family jaundice, congenital and acquired, the chronic infective jaundice of Hayem, the simple family cholemia of Gilbert, the various forms of hemolytic icterus with splenomegaly of Banti, Chauffard, and others. Clinically there are transition cases between hemolytic icterus and biliary cirrhosis and between hemolytic icterus and pernicious anemia. The rôle of the spleen in the hemolysis which is a chief feature of the varied groups has been emphasized in recent years from many laboratories and clinics. Splenomegaly is the rule. In some instances the jaundice may be definitely hematogenous, the degradation of hemoglobin occurring elsewhere than in the liver. Chronic hemolytic icterus is of varying and usually of slight degree. Bile is absent from the urine but is present in increased amount in the blood serum. Urobilin is present in the urine and usually present in increased amounts in the stools. There may be moderate or grave anemia, frequently there is abnormal fragility of the erythrocytes, microcytosis, and great increase in the number of erythrocytes with basophilic granulations.

Symptoms. I. *Obstructive Jaundice.*—1. Staining of the tissues is most striking and is due to bilirubin. Connective tissue has particular affinity for the pigment. The conjunctivæ usually show the earliest tinge; the color is well seen in the mucous membrane of the hard palate, especially on pressure; color of the skin varies from sulphur, lemon, or saffron hue in slight cases to greenish, bronze, or even greenish black in chronic cases with complete obstruction. The pigmentation is most marked over the forehead, temples, scalp, upper extremities, and thorax. The pigment lies in granular masses in the deepest layers of the rete Malpighii, and may persist ten or twenty days after it has disappeared from the blood. The cornea, peripheral nerves, cartilage, hair, and teeth usually escape stain; the brain is not colored, except in the new-born; the fetus may be lightly jaundiced. Langmead and Thursfield have found the teeth stained green in infants with long-continued jaundice. 2. Nearly all secretions show presence of bilirubin. It can be demonstrated in the urine, sweat, exudates, amniotic fluid, and pus; it is inconstant in the milk, rarely present in the sputum except in pneumonia, has been demonstrated exceptionally in saliva, but is not found in the tears. The urine is usually dark yellow or brown, sometimes reddish or greenish. The foam is yellow, immersed filter paper is stained yellow, and the presence of bilirubin can be shown by a number of tests. In the Smith-Rosin test, 3 c.c. of a solution of tincture of iodine diluted ten times with alcohol is added to 10 c.c. of urine; a green ring forms at the zone of contact. Gmelin's test: Fuming nitric acid is poured beneath a layer of urine in a conical glass; a play of colors occurs at the zone of contact yellow, green, blue, violet, to red; the green color is most characteristic. The Schwerdtfeger-Huppert and Gluzinski tests are equally delicate but less convenient. If the serum contains only slight quantities of bile pigments, the urine may contain only urobilin and no bilirubin. The urine is yellowish red and only rarely brownish red. Urobilin occurs in small quantity in normal urine, occurs in the feces as stercobilin, may occur alone in the urine in slight jaundice, at the beginning or end of severe jaundice, usually disappears from the urine when bile is totally shut off from the intestine. It is a reduction product of bilirubin or hemoglobin, and reduction may occur either in the intestine or in the tissues. There is no true urobilin icterus; the staining of the skin is always by bilirubin. To test for urobilin, water is poured carefully over the urine in a test-tube; urobilin diffuses more rapidly than bilirubin, and may be recognized with the spectroscope (Hayem). Fluorescence may be shown by the method of Schlesinger—adding to the urine an equal bulk of ten per cent. alcoholic zinc acetate solution and filtering. The following table of Quincke, little modified from that of Hayem and Tissier, shows the shifting relations of the bile pigments in urine, feces, and skin in the course of ordinary obstructive jaundice:

	Skin.	Serum.	Urine.	Feces.
1.	Very slight yellow	Bilirubin 0	Bilirubin 0 Urobilin 0 or little	Normal color.
2.	Light yellow	Bilirubin +	Bilirubin — Urobilin —	Colored.
3.	Yellow	Bilirubin +	Bilirubin + Urobilin +	Pale.
4.	Deeply yellow	Bilirubin +	Bilirubin + Urobilin — or 0	Clay color.

Besides bilirubin and urobilin the urine contains bile acids and at times nucleo-albumin and albumin. Bile-stained cells and hyaline and finely granular casts are found in all jaundice urines.

3. Pruritus is frequent, and in marked jaundice may be severe and tormenting. It is an intoxication symptom, and largely modified by individual peculiarity; it may precede the jaundice, and in fact be present for long periods without jaundice, as in hepatic cirrhosis; but as a rule it is not intense save in complete and long-standing obstruction. It may cease when bile reappears in the stools, though the skin still remains colored. Urticaria, eczema, fissures, and boils occur as a result of scratching. Xanthoma, xanthelasma, or vitiligoidea is a peculiar condition characterized by formation of yellowish flat patches or tubercles; the flat variety occurs on the eyelids, the tubercular form elsewhere on the skin or in the viscera. The association with icterus is not a necessary one. Sweating is frequent and may be confined to the back or abdomen. Telangiectases may develop in chronic cases in the skin and occasionally in the mucous membrane of the tongue and lips. Clubbing of the nails has been occasionally observed, and periosteal nodes may form.

4. The color of the feces may be modified. In total obstruction the stools may be pasty and more or less grayish white or clay colored. The color is due partly to absence of modified bile pigment, and partly to the large amount of undigested fat; according to F. Mueller, from fifty-five to seventy-five per cent. of fat goes to waste when bile is wholly shut off from the intestines, instead of normally from seven to ten per

cent. With partial obstruction the stools are more colored; return of color may be the first sign of relief from total obstruction. Formerly much stress was laid on the antiseptic properties of bile, but we now know that the bile has little influence on bacterial growth and controls but little the odor of the feces.

5. Slow pulse is a common symptom, especially of catarrhal jaundice. It is difficult to understand the experience of Mackenzie who states that he has never seen bradycardia with jaundice. The phenomenon is variously attributed to action of bile acids on the vagus, heart muscle, or intracardial ganglia; irritation of the vagus is the most probable cause, for Wintrend has demonstrated a rise from 40 to 120 after atropine injection. Later, in a chronic jaundice, an originally slow pulse may rise to normal or increased rate. King and Stewart have shown experimentally that the bile pigments and not the bile acids are the cause of the bradycardia.

6. Disturbances of vision are rare—xanthopsia, hemeralopia, nyctalopia.

7. Digestive disorders are common but equivocal. The usual complaints are of anorexia, bitter taste in the mouth, distaste for meats or fats, flatulence, constipation, or occasional diarrhea.

8. Nervous symptoms are of many kinds. Physical and psychical weakness, depression, irritability are present in mild cases; with persistent jaundice severe disturbances may occur. The general condition grows worse, a typhoid state develops, dulness and stupor deepen into coma that proves fatal, coma alternates with states of excitement and delirium, or general convulsions of indefinite nature end the scene. The symptoms directly suggest intoxication, and the condition has long borne the name of cholemia. The name is not a good one, as the same group of symptoms may terminate a cirrhosis of which jaundice forms no part. It is an autointoxication of complex kind, as shown by the variety and inconstancy of the symptoms. The term hepatic intoxication, proposed by Quincke, should supersede cholemia.

9. Hemorrhage. The presence of bile constituents slows coagulation of the blood, and in long-continued icterus, instead of the normal time of three and a half to four minutes, coagulation may be delayed to eleven or twelve minutes (Osler). The tendency to bleeding is shown in spontaneous hemorrhages—purpura, suggillations, more rarely bleeding from mucous membranes, or by profuse and fatal hemorrhage after operations. It is well known that surgeons operate with dread in cases of long-standing jaundice. Mayo Robson would refer the tendency to bleed in chronic jaundice to involvement of the pancreas. In some cases the formation of fibrinogen is at fault.

II. *Toxemic Jaundice.*—In this form obstruction depends upon increased viscidity of bile, due to blood changes or to catarrh of small bile ducts; no obvious obstruction is to be found in large ducts. Bile is never absent from the feces; in fact, the stools may be very dark from excess of bile (polycholia). The bile acids are not constant in the urine, but this is of no clinical importance. Coloring of the skin is usually less deep, constitutional disturbances are as a rule decidedly more marked; the jaundice seems often merely a symptom of a general infection. All the cases of this group present about the same clinical picture; differences in the symptoms and course are due to the variety and especially to the intensity of the intoxication. There may be gradations from an apparently simple epidemic catarrhal jaundice to the syndrome of malignant jaundice or Weil's disease, or to the severest type of icterus gravis or acute yellow atrophy.

Morbid Anatomy and Course.—The pathological findings of icterus vary widely with the causes; they are sufficiently discussed in connection with symptomatology or in the sections dealing with the special diseases. The course and prognosis vary also with the cause; in general, prognosis is less good when obstructive jaundice has lasted three or four months; after eight to twelve months liability to hemorrhage or to sudden severe nervous symptoms renders the outlook unfavorable. Budd, however, cites recovery after four years; Murchison, Barth, and Bismer report a favorable termination after six years' duration; Legendre, Gailliard, and Debove mention cases of complete obstruction of twelve, twenty, twenty-five years' standing without much general disturbance!

Varieties of Jaundice. 1. *Icterus Neonatorum.* Jaundice of the new-born may be (*a*) severe, due to congenital stricture or absence of the bile ducts, to syphilis, or to sepsis; this form rapidly proves fatal; (*b*) mild or physiological. This occurs in one-third or two-thirds of all infants born in hospital, and in a somewhat smaller per cent. of private cases. It is more frequent in boys, in premature infants, in cases in which chloroform was used, or in cases attended with marked congestion. The jaundice appears on the second or third day, is most marked in the face and upper part of the body, as a rule is not deep, the conjunctivæ are stained only in severe cases, there is little or no general disturbance, the color fades in from a few days to three or four weeks. The urine, as a rule, is of normal yellow color and contains no soluble bile pigment; it frequently shows traces of albumin, and the sediment may show bile-stained kidney epithelium or cells enclosing granules or crystals of bilirubin. Bilirubin is held in the kidney in the form of infarcts. There is no urobilinuria; the feces are of normal yellow color. Pathogenesis is obscure. The benign character shows the practical physiological nature of the process; it may depend in part on the increased blood destruction and consequent polycholia of the first days after birth, in part on the slow excretion of bile by the kidney (infarct formation), in part on lack of bile reduction in the intestine. More probable is the explanation of Franck and Quincke that the icterus depends on increased bile absorption from the intestines; the meconium contains bilirubin, bile secretion is increased with ingestion of the first food, bile is consequently absorbed in quantity into the portal blood, and in the first few days patency of the ductus venosus Arantii allows the bile constituents to enter in part the vena cava and so reach the general blood stream without passing the liver.

2. *Icterus after Hemorrhages.*—Definite icterus has been observed after blood extravasations and internal hemorrhages. The staining appears in from three to ten days after the hemorrhage, is of slight degree, and fades in a few days or weeks. Urobilinuria accompanies and, in fact, precedes the jaundice; it is extremely rare to find bilirubin in the urine. Elaboration of the bile pigment probably does not take place locally; hematoidin crystals may form, but this is a slow process and the crystals show little tendency to solution. More probable is the solution of hemoglobin *in situ* and its transformation into bilirubin in the liver; the jaundice is hepatogenous, an icterus pleiochromicus. With small extravasations no jaundice occurs, only urobilinuria.

3. *Inanition Icterus.*—Slight staining of the conjunctivæ or skin may occur in inanition or starvation. Trendelenburg observed a case with slight bilirubinuria. It is a common event to find bile in the urine of fasting dogs—the absorption occurs within the liver.

4. *Icterus Syphiliticus.*—This is the icterus syphiliticus precox. It occurs in the secondary stage, is not frequent, occurs oftener in women (Fournier). The cases show generally severe secondary symptoms, eruptions, and marked glandular enlargements (Werner). It is a mechanical jaundice and due to swelling of the glands in the portal fissure (Lancereaux). In one case Quincke observed ascites and splenic tumor coming and going with the jaundice.

5. *Icterus psychicus, Icterus spasticus, Icterus ex emotione.*—In the minds of the laity the emotions play a large part in liver pathology. The only cases of jaundice that can be ascribed to nerve influence are those which occur within a few hours or even minutes after a sudden nerve shock, as fright, anger, fear. There are two classes of such cases: 1. Jaundice coming on immediately after severe shock; in all literature examples of this class are extremely rare; two cases of Villeneuve (1818) are cited by Murchison. 2. Jaundice occurring a few hours after great nerve shock or strain. This is comparatively common; the jaundice is light and of short duration; in a few cases acute yellow atrophy has followed. Various explanations have been advanced—polycholia, lowered portal pressure (Frerichs). The most probable explanation is that of spasmodic contraction of the bile ducts with increased back pressure and quick absorption.

HERBERT C. MOFFITT.

Jaundice, Acute Infectious.—See *Weil's Disease.*

Javal, Louis Emile.—Born in Paris, France, May 5, 1839. He received his doctor's degree in 1868. In 1878 he was made Director of the Laboratory of Ophthalmology of the École des Hautes Études, in Paris. The majority of his published writings, which deal almost exclusively with physiological optics, will be found in the *Annales d'oculistique.* Javal's ophthalmometer is a well-known instrument. He died in 1907. A. H. B.

Jaws, Injuries and Diseases of the.—Because of the necessary brevity of this article it is to be understood at the outset that many details are omitted and that all wound treatment, whether operative or not, is to be conducted according to modern aseptic and antiseptic surgery so far as possible.

INJURIES AND DISEASES OF THE UPPER JAW.—In dealing with the upper jaw it must be borne in mind that: (1) Its periosteum is not osteogenetic; (2) because of its extreme vascularity reparation after injury is wonderfully active and complete; (3) it contains the largest of the accessory nasal sinuses, the antrum of Highmore. This cavity is situated in the body of the bone, and is lined with mucous membrane continuous with that of the nasal cavity through a small orifice opening into the middle meatus.

FRACTURES OF THE UPPER JAW.—Because of its thin walls and the manner in which it is hollowed out it is readily fractured when traumatized, but owing to its position, protected on all sides by its outlying processes of bone—the malar bone externally and the nasal bones internally—fracture is not a very frequent accident. Almost invariably, fracture of this bone is associated with fracture of the more prominent bones of the face with which it is articulated. Direct violence, such as blows upon the face, falls from great heights, etc., is usually the cause of the fracture. However, it can be caused by a blow upon the head when the chin is fixed; or a blow upon the chin may cause a fracture of this bone while the lower jaw escapes.

The fracture may be of the penetrating variety, consisting of a small opening into the antrum made by a sharp-pointed instrument, which may enter by way of the orbit, the palate, the nostril, or the anterior wall of the cavity. Such wounds, as a rule, heal rapidly and require but little attention on the part of the surgeon.

Fracture may involve any part of the bone—the nasal, palatal, alveolar process, or the body of the bone.

As the result of falls upon the face from great heights, the fracture, in a few recorded cases, has been vertical in the median line, constituting a diastasis or separation of the two superior maxillary bones. Comminuted fractures, attended with the most frightful deformity, as the result of gunshot wounds, are occasionally met with. When the alveolar process is separated from the body of the bone, there is usually marked displacement.

The anterior wall of the antrum of Highmore is sometimes crushed in by fragments of the malar bone driven down upon it by the force of blows. In such cases impaction is the rule, the discomfort is no greater than that following a simple contusion, and the deformity is often masked by the swelling. The soft parts overlying the bone are nearly always extensively involved. Hemorrhage from wounds of branches of the external carotid artery is occasionally very profuse—sometimes requiring the application of the actual cautery to the bleeding point or even ligation of the external carotid artery.

When a fracture of the nasal process of the superior maxilla is complicated with a fracture of the nasal bones in which the mucous membrane of the nose has been more or less lacerated, extensive emphysema of the face may take place.

If the line of fracture runs through the infraorbital foramen, causing contusion or laceration of the infraorbital nerve, temporary sensory paralysis of the parts supplied by that nerve may ensue.

Obstruction of the lacrymal duct, with a constant overflow of tears upon the cheek, may follow fracture of the upper jaw.

Signs and Symptoms.—In the majority of cases recognition of fracture of the upper jaw is not difficult. Deep-seated pain, increase of saliva, hemorrhage from the mouth or nose, and the special signs of fracture, viz., crepitus, preternatural mobility, and deformity, are all present in greater or lesser degree. The accessible position of every part of the bone makes it usually an easy matter to detect a fracture of the maxilla.

Treatment.—In the treatment of fractures of the upper jaw the indications are to replace, by manipulation, the fragments as accurately as possible, and by suitable appliances, to render them immovable. Pressing the lower jaw firmly against the upper with a Barton bandage will in most cases suffice.

If the tendency to displacement is great, as in fractures of the alveolus, it may be necessary to wire the teeth of opposing fragments together, or to adjust an interdental splint. If wire is used it is best to include several teeth on either side of the line of fracture, otherwise the teeth become loose and the wiring does only harm.

If the malar bone is driven into the upper jaw we can reduce the deformity: (1) By introducing a blunt instrument through the mouth under the zygomatic process and by pressure elevating the fragment. (2) Following the method of Erdmann we can reduce the deformity by using bullet forceps, placing one prong just back of the orbital ring and the other through the cheek just below the prominence of the malar bone. By making extension with the instrument the deformity is usually easily reduced. (3) Should these methods fail then it may become necessary to enter the antrum, preferably by chiselling or trephining an opening through the canine fossa, and with a blunt instrument or the finger elevate the depressed bone and immobilize it by packing the cavity with gauze. The packing can be removed on the fourth or fifth day.

When any fracture of the superior maxilla is comminuted and compound, great care should be taken to preserve every fragment, however loosely attached, as the experience of a great many surgeons has shown that such fragments unite very readily. Another point to be observed in the treatment of fractures of the upper jaw is not to extract loosened teeth, since, in addition to the fact that they most frequently become firm again, their extraction is attended with

some danger of removing fragments of bone that might have been preserved.

Inflammation.—This usually manifests itself in the form of an acute or chronic periostitis.

Acute Periostitis.—Mechanical injury, mercury, phosphorus, the exanthematous fevers, and the diathetic diseases, *e. g.* syphilis, rheumatism, gout, and tuberculosis, all predispose to this affection. The commonest predisposing cause, however, is the irritation set up by carious teeth. It is needless to say that some form of microorganism is the exciting cause.

Signs and Symptoms.—Severe pain of a throbbing, tensive character, aggravated at night, exquisite tenderness when the tooth is pressed into the socket, as in mastication; swelling of the cheek, often so great as to distort the features. Later suppuration takes place, pus forms, and there is a rise of temperature which continues until the pus escapes.

Treatment.—In order to avert suppuration the treatment should be prompt and active. All decayed teeth should be at once removed as the most probable cause of the mischief. Saline cathartics should be exhibited, local depletion by means of free incisions, together with hot antiseptic fomentations, should be employed. In order to prevent recurrence local and constitutional treatment should be instituted.

Chronic Periostitis (Pyorrhea Alveolaris).—This may arise from repeated attacks of the acute form, though it oftener occurs as the result of some constitutional disease which by lowering the vitality invites bacterial infection.

Signs and Symptoms.—These are often of the acute type somewhat modified. Sometimes it is absolutely painless, in which cases it is discovered only by accident. Pressure on the swollen gums may cause pus to escape from around the necks of the teeth. Of late pyorrhea alveolaris has received much attention because of the fact that it seems to be an etiological factor in certain constitutional diseases and infections, *e.g.* chronic arthritic rheumatism, gout, high blood pressure and its sequelæ, and grave anemia.

Syphilitic periostitis differs from ordinary chronic periostitis in that there is a marked tendency to the development of gummata and nodes. The former often break down and discharge their caseous contents, while the latter may lead to eburnification of the bone.

Treatment.—Local treatment of the most thorough type should be undertaken by a competent dentist before the disease leads to falling of the teeth and absorption of the alveolar process. The constitutional treatment should be symptomatic.

Alveolar Abscess.—The immediate effect of inflammation at the root of a tooth, may be superficial or deep. When superficial it is commonly known as gumboil, which is recognized as a puffy swelling of the gums, globular in form, usually small in volume, but often exquisitely tender and painful. This form of abscess, after a brief period, ruptures spontaneously or upon slight pressure with the finger, and recovery speedily ensues.

The deep alveolar abscess, which more directly results from diseased teeth, commences in the substance of the bone. The abscess cavity, at first very small, rapidly increases in size, the alveolar process becoming carious and undergoing absorption. The pus may find an outlet for itself by the side of a tooth, or, if resistance in that direction is too great, the alveolar process may be perforated and the pus then burrows beneath the mucous membrane. Occasionally pus burrows beneath the periosteum of the palate, afterward pointing in the roof of the mouth.

Treatment.—The treatment is free incision and extraction of the peccant tooth. This should be done early, as delay may lead to extensive necrosis, or to the formation of a long sinus, most difficult to heal.

Empyema of the Maxillary Sinus.—While the irritation set up by diseased teeth, especially the molar teeth, often produces this condition, the consensus of opinion among leading specialists of to-day, is that the origin of the trouble can usually be traced to the nose or some of its accessory sinuses. And the fact that the frontal, ethmoidal, and sphenoidal sinuses are so often the seat of suppuration is a point in favor of this view, since none of them are touched by teeth.

Any condition in the nose interfering with efficient drainage through the natural ostium will naturally tend to bring on this trouble, hence it is found that acute or chronic rhinitis, influenza, a deflected septum, and disease of the middle turbinate bone are important etiological factors. It occurs often in the course of pneumonia and those suffering from tuberculosis seem somewhat prone to the disease though tuberculosis of the lining membrane of the antrum is rare. Aerobic and anaerobic bacteria are both found in the secretion, the former usually in those cases which can be traced to the nose or accessory sinuses, the latter in cases where the trouble results from carious teeth.

Diagnosis.—In acute cases the history usually points to a recent nasal infection, such as acute rhinitis, influenza, involvement of the frontal sinus, or prolonged suffering with decayed teeth. The patient complains of severe pain in the head, face, and teeth on the side involved and there may be some swelling of the face, or, if a tooth is the cause of the trouble, the gums may be swollen and tender. Occasionally the pain lessens temporarily after a large quantity of pus is forcibly blown from the nose. Examination of the nose will show an accumulation of pus in the middle meatus which recurs after swabbing the part, especially if the patient lies down or forcibly blows the nose. In the chronic cases diagnosis is often very difficult because the symptoms point almost as much to the frontal as to the maxillary sinus. Since both of these cavities drain into the middle meatus, simple intranasal examination is of little value. Here transillumination and the Röntgen ray may help clear up the diagnosis, or by irrigating both of these sinuses we may locate the disease. However, one of the best and easiest methods is to aspirate the maxillary sinus through the middle or inferior meatus of the nose. If pus is found then treatment must be directed here. In those chronic cases when there exists no means of escape for the pus and it accumulates in the cavity, the bone becomes expanded, the cheek is pushed forward, and the walls of the antrum become so thinned by absorption, that when pressed upon a peculiar crackling sensation is felt. The bone may be expanded upon any or all of its surfaces, orbital, buccal, palatal, or nasal. In several recorded cases the pressure upward has caused exophthalmos with permanent amaurosis. Lacrymation, blepharospasm, transient amblyopia are also sometimes produced.

Treatment.—The acute form is best handled conservatively. An initial dose of calomel followed by salts, anodynes for the pain, continuous hot applications locally and an expectorant mixture internally to liquefy the tenacious secretion. Hexamethylenamine should also be given in rather large doses because of its antiseptic action. It is hardly necessary to mention the importance of locating and removing the cause.

The chronic form requires a more radical treatment. Irrigation of the antrum through the natural opening may bring about a cure, but since the opening into the nose is higher than the antral floor, efficient drainage is impossible and attempts to cure the disease in this way are often futile. The most important indication is to secure thorough drainage. This can be done by entering the antrum through the socket of an extracted tooth, through the bone above the alveolar process, or through an opening in the lateral wall of the nasal cavity. The latter method

usually answers all requirements and will often bring about a cure in five or six weeks. Under local anesthesia, the mucous membrane of the inferior meatus is incised and an opening through the thin bone made with a knife, this opening is then enlarged with a special saw and the excess of mucous membrane cut away. Drainage through this opening is efficient and daily irrigations with antiseptic solutions are easily and painlessly conducted.

If it is impossible to perform the above operation because of extreme narrowness of the nasal cavity, then it may be necessary to resort to one of the so-called external operations. One of the best of these is the Caldwell-Luc in which the lateral wall of the inferior meatus is opened after the antrum is entered through an opening in the bone above the alveolar process. The main advantage of this operation is that the antrum can be well examined and its walls curetted if necessary at the time of operation. After making the opening into the nose and inserting gauze packing in the antrum with an end protruding through the nasal opening, the buccal opening is closed with sutures. The diet for several days must be liquid in order to minimize the danger of infection of the buccal wound.

Cystic Disease of the Antrum.—In this disease the antrum becomes distended by a dark-colored, glairy, and in some instances gelatinous fluid, which frequently contains cholesterine in considerable quantity. The old name applied to the disease was hydrops antri, or dropsy of the antrum, and it was supposed to depend upon the retention of the natural secretion of the mucous membrane lining the sinus, the escape of which had been prevented by the closure of the opening between the antrum and the nose; but modern research has shown that such a view was not correct. The cysts most likely depend upon cystic degeneration of the glandular follicles thickly aggregated over the mucous membrane lining the cavity.

Signs and Symptoms.—The disease is of painless growth and the expansion of the bone is gradual.

Fig. 3553.—Cystic Tumor of Antrum. (Erichsen.)

In course of time it leads to marked deformity—the cheek becomes prominent and round, the eye protrudes from the orbit, the nose is pushed to the opposite side, the nostril becomes occluded, and the palate is depressed, often to such an extent as seriously to embarrass deglutition. The enlargement presents itself as a rounded tumor, soft and elastic at some portions of its surface, hard and resisting at others. Pressure upon the swelling often elicits the peculiar egg-shell crackling characteristic of those conditions in which the bone is greatly expanded and thinned. The general appearance of the disease closely resembles that of solid tumors of the upper jaw, which fact has caused surgeons, in a number of instances, to excise the entire upper jaw unnecessarily. In all doubtful cases of swelling of the upper jaw, therefore, exploratory punctures should be made before resort is had to the more serious operation of excision.

Treatment.—Acting upon the false belief that the enlargement consisted of the pent-up secretion of the antral mucous membrane, surgeons formerly attempted to reëstablish the normal opening between the sinus and the nasal cavity, but naturally such a procedure never met with success.

The proper treatment consists in the evacuation of the contents of the cyst by means of free incisions, and the establishment of efficient drainage until the tendency to recurrence no longer exists. This may be easily accomplished by incising the most prominent part of the tumor, usually beneath the cheek, evacuating the contents through the opening, and dilating the passage thoroughly with the finger. If the cyst is large, a portion of the bone or of the cyst wall should be cut away. The cavity should be thoroughly washed out, several times daily, with some stimulating antiseptic solution until all discharge ceases. The deformity occasioned by the distention of the bone will eventually entirely disappear.

Polypus of the Antrum.—This form of morbid growth in the antrum is rare, though a polypoid degeneration of the antral mucous membrane is often the result of an empyema of the maxillary sinus. Like polypus of the nasal cavity, to which it is similar in pathology, it takes its origin from the mucous membrane, and may be either fibrous or myxomatous, most frequently the latter.

When small its presence is unsuspected, and it is only after it has attained considerable dimensions and has, by its size, led to absorption of the thin internal wall of the antrum and protruded into the nostril, that the real nature of the disease is manifested.

Until this growth reaches large dimensions, surgical interference is rarely called for. Thorough removal, by opening up the anterior wall of the antrum, or through the nose if possible, is the proper method of treatment. In operating it should be remembered that polypus is often the starting-point of a carcinoma and removal should therefore be complete.

Lipoma.—Fatty tumors of the jaw are very rare, only a few cases having been reported.

Fibroma.—Fibrous tumors of the upper jaw may be either endosteal or periosteal in origin, and may occupy the antrum of Highmore or grow from the alveolar process, the latter variety being known as fibrous epulis. In structure, fibromata are similar to fibrous tumors in other parts of the body, and are liable to the same kinds of degenerative changes.

The upper jaw is not so often the seat of endosteal or central fibromata as the lower.

Frequently these growths contain spicula of bone or nodules of cartilage, either of which may be present in large quantity.

Etiology.—Aside from the fact that some cases are known to follow a trauma or to develop after long-continued irritation from decayed teeth nothing is known of their origin. Though some think they, like the odontomata, arise as the result of perverted tooth development, there is practically nothing to substantiate their claims.

Diagnosis.—Fibromata usually occur in adolescence and young adult life, seldom after the age of forty. Their growth is slow but sometimes they reach enormous dimensions. When originating within the antrum, a fibroma may extend in every direction, the bony walls undergoing absorption, give way before it, allowing processes of the tumor to extend into the mouth, nasal cavity and the orbit, giving rise to the most hideous deformity. Such tumors are apt to be considered malignant unless a microscopical examination is made, even though we take into consideration

its slow and painless growth, the lack of adhesions to surrounding tissues and the non-involvement of the lymph nodes.

Treatment.—When the tumor is located within the antrum and is of moderate size, it may be possible to enucleate it from within the mouth without disfigurement of the face. This may be accomplished by dissecting the cheek from the bone and entering the antrum through its anterior wall. If situated elsewhere, the tumor including some of the adjacent bone and periosteum must be removed as conservatively as possible. If, however, the growth is large and has in a measure substituted itself for the upper jaw, nothing less than complete excision of the bone will suffice.

Epulis.—This tumor may be a pure fibroma or it may be sarcomatous in nature. Scudder writes: "An epulis is a border-line tumor: it lies midway between inflammation, on the one hand, and a neoplasm, on the other. When looked upon as a neoplasm, it is still a border-line lesion between the benign and the malignant connective-tissue tumors." It grows from the periosteum of the alveolar process close to the junction of the gum with the teeth, between the teeth, or even from a tooth socket after pain has led to the extraction of the tooth. It grows slowly and usually painlessly, and seldom reaches a large size, though a few cases have been reported in which such outgrowths have attained sufficient volume to cause considerable deformity. Often adjacent teeth become loosened and eventually drop out.

Etiology.—It occurs oftener in women, and usually after the age of thirty. Irritation from decayed teeth

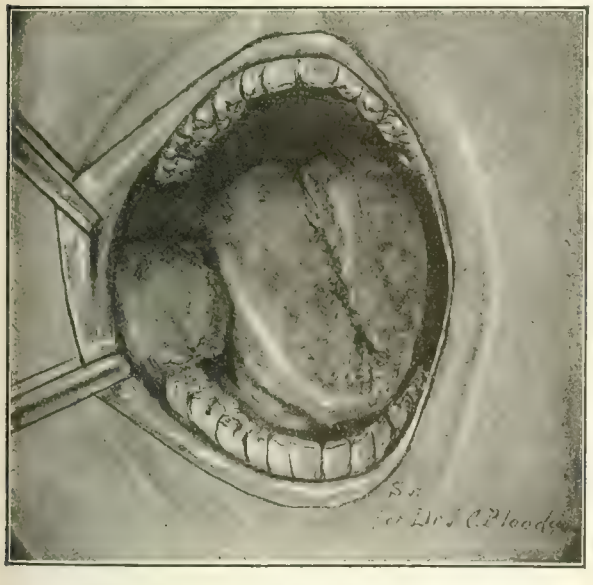

Fig. 3554.—Giant-cell Epulis of Right Lower Jaw; Painless growth three years in man aged 50 years. The last two molars were lost after the appearance of the tumor. (Bloodgood, Am. Practice of Surgery.)

seems to be an etiological factor. Since trauma occasionally causes the growth to increase rapidly, this too might be considered as one of the causes. Pregnant women are attacked oftener than others.

Signs and Symptoms.—Examination discloses a small, more or less immovable, hard tumor which has existed for some time, growing from the alveolar periosteum. If it is of the fibrous type, the mucous membrane is but slightly injected, it is hard to the touch and there is seldom any ulceration. If on the other hand it is sarcomatous in nature, the mucous membrane is bright red in color, perhaps ulcerated, the tumor is soft and bleeds easily upon examination.

Diagnosis.—The differentiation of this form of tumor from pure sarcoma and from carcinoma is made by its slow growth and relatively painless development, and from carcinoma especially by the age of the patient and lack of glandular involvement. The acute onset, severe pain, and presence of pus in alveolar abscess make its exclusion easy, while the absence of one or more teeth and fluid on aspiration are aids in preventing confusion with the odontomata. As with all other tumors, however, the microscope is the best and surest means of diagnosis.

Treatment.—If microscopic examination at the time of operation shows the tumor to be a pure fibroma, thorough removal of the tumor and underlying periosteum, followed by cauterization of the base will be sufficient. If however giant cells are present, if the tumor has shown any signs of malignancy, nothing short of resection of the tumor-bearing segment of the alveolar process will suffice to prevent recurrence.

Chondroma.—Tumors composed of pure hyaline cartilage in the upper jaw are extremely rare. Usually the neoplasm contains fibrous, osseous, or sarcomatous tissue cells. If these tumors grow from the surface of the bone they are called ecchondromata, if from within the bone, enchondromata. Chondromata may reach immense size. Like the fibromata, their growth is usually very slow but those containing sarcomatous tissue differ from the fibromata in that they grow rapidly and have a tendency to recur. In fact many cases have been reported in which repeated operations were necessary, the tumors seeming to become more malignant with each recurrence. It is this tendency to recur that has lead to the classification of chondromata into the benign and the malignant.

Treatment.—The treatment of chondromata should be the same as that for fibromata, except that the surgeon should be even more careful to go wide of the capsule which is usually present, in order to guard against recurrence.

Osteoma.—Osteomata are more frequently met with in the lower than in the upper jaw. This form of tumor in its structure possesses all the characteristics of true bone. It may be cancellous in structure, enclosed in a thin casing of compact bone, or of denser consistence, hard and compact throughout like ivory. They occur very often at the age of puberty.

Hyperostosis is a disease of the jaw which consists of a diffused hypertrophy of the bone, with frequently total obliteration of the antrum. Partial hyperostosis may take place in the alveolar process as the result of irritation proceeding from a misplaced or diseased tooth.

Osteomata of the upper jaw have been known to become loose in their attachments, and finally to become spontaneously detached.

It is not an easy matter to differentiate an osteoma from a chondroma, or even from a fibroma, but its slow growth, extreme hardness, and irregular, nodulated, or tuberous surface will be of service in making a diagnosis.

Treatment.—Osseous tumors of the upper jaw should be removed with the part of the bone from which they grow, or if large and the source of great deformity, the entire jaw should be excised.

Sarcoma.—Sarcomata are tumors of connective-tissue origin, made up chiefly of embryonic cells. Here as elsewhere, they are essentially malignant in nature, being almost certain to recur after removal, and in their growth infiltrating adjacent tissues. The sarcomata are very vascular and grow rapidly, often reaching immense volume. They occur oftener in the lower jaw. They are histologically divided into three classes, namely, the spindle-celled, the round-celled, and the giant-celled.

Clinically they are classified according to origin into periosteal and medullary. There are often several types of connective tissue present in the same tumor, hence a further classification into osteo-, fibro-, chondro-, myxo-, angeio-, lympho-, and melano-sarcomata. The spindle-celled type is most frequently found in the antrum. It closely resembles the fibroma macroscopically. The medullary sarcoma is oftener made up chiefly of giant cells. The periosteal sarcoma may contain any type of cells though, as a rule, the spindle and round cells predominate. Should giant cells only be present, together with a large

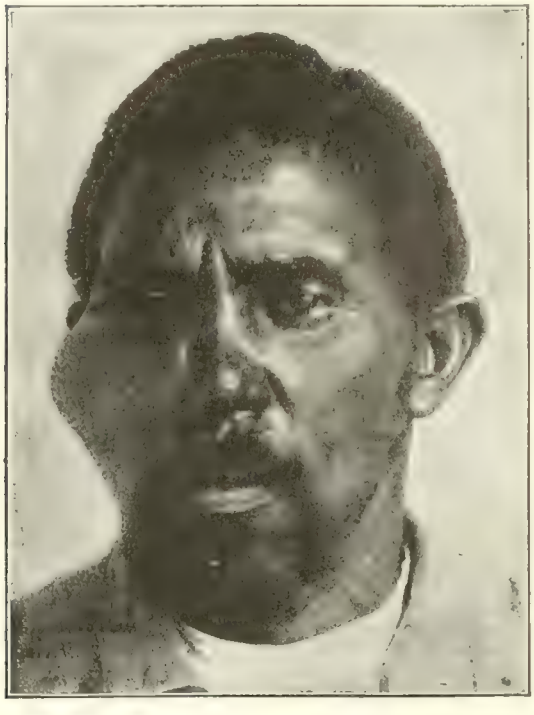

Fig. 3555.—Inoperable Sarcoma of the Upper Jaw in a Man Aged 50 Years. (Bloodgood, Am. Practice of Surgery.)

amount of fibrous tissue, then in all probability the tumor should be classed as a sarcomatous epulis rather than a pure sarcoma.

Etiology.—Trauma seems to be the most important single etiological factor, here as elsewhere a definite relationship between sarcoma and trauma having been shown by Coley and others. A history of dental caries, toothache, or extraction of teeth is often given by the patient, but in such cases it is manifestly impossible to differentiate cause and effect.

Sarcoma seldom occurs after the age of fifty, and though in other parts of the body it occurs oftener in childhood and adolescence, in the upper jaw sarcoma is very unusual in children.

Diagnosis.—When the tumor, whether periosteal or medullary, grows into the antrum it pursues the same course as other solid tumors of that cavity, causing enlargement of the bone, bulging of the cheek, parchment-like crackling on palpation, etc., but differs from them in that it grows more rapidly, is more prone to ulcerate and cause empyema, and is more vascular so that hemorrhage from the nose is commoner than with non-malignant neoplasms. Pain may or may not be present.

If the growth is situated on the alveolar process, the extreme vascularity as manifested by the injected mucous membrane, the softness, and tendency to bleed on slight trauma may put the surgeon on his guard. But since sarcomata sometimes grow slowly, since slow growth is not always a sign of benignancy, and since fibrous, osseous, or other connective tissues may predominate to such an extent as to mask the malignancy of the growth, the microscope alone should decide the diagnosis.

Treatment.—No matter how thoroughly sarcomata of the upper jaw are removed, their malignancy is manifested by the fact that in the majority of cases they recur. Recurrence is local rather than by metastases. Often the small, slowly growing tumor will recur with an awful malignancy, while the larger, more rapidly growing tumor, if thoroughly removed will not return. This fact alone should lead the surgeon to be sure of his diagnosis in operating on even the most innocent-looking tumor of the jaw and if the microscopic diagnosis at the time of operation pronounces the tumor malignant, then nothing short of a radical operation, even removal of the entire upper jaw if necessary, will suffice.

If the case has progressed so far that operative removal is impossible, then the surgeon can try ligation of the external carotids, injections of Coley's fluid, radium, the Röntgen rays, and large doses of some of the arsenical preparations, such as sodium cacodylate or salvarsan. Da Costa reports a case of Keen's in which the eye, half the superior maxilla, the orbital plate, and the walls of the frontal sinus were removed, the dura exposed and the wide gap filled with a flap of tissue from the scalp. This patient lived for three years. This case alone shows that the surgeon should use careful judgment before pronouncing any case inoperable.

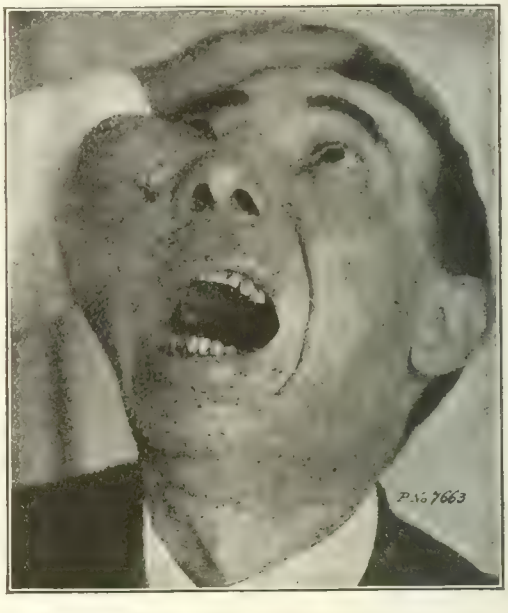

Fig. 3556—Carcinoma of the Antrum Secondary to Nasal Polypi, in a Man of 41 Years. (Bloodgood, Am. Practice of Surgery.)

Carcinoma.—There are two distinct varieties of carcinoma of the upper jaw, the squamous, which grows from the gums or the mucous membrane covering the alveolar or palatal processes of the superior maxilla; and the columnar, which always commences in the nasal cavity or the antrum. These tumors never start in the bone itself but only involve that structure by extension.

The squamous-celled carcinoma usually commences as a small ragged ulcer of the gums or palate. As the ulcerative process extends, the bone gives way before it and the antrum is involved. This cavity soon becomes filled with the carcinomatous deposit and the

surrounding tissues are rapidly infiltrated. The antrum becomes overdistended with the mass, the walls yield, the cheek bulges, the nostril is occluded, the orbital plate is encroached upon, and the eye protrudes. The skin over the tumor is stretched and eventually becomes livid, breaks down and an irregular ulcer is formed through which protrudes a fungous mass, from the surface of which a fetid, thin, mucopurulent fluid is constantly discharged. Profuse hemorrhages from such an ulcer or from the nose are not infrequent. Such in general is the local progress of the disease, whether it commences in the antrum itself or on the gums or alveolar mucous membrane and later involves that cavity. If, however, it commences in the antrum an empyema is sometimes its first manifestation.

Etiology.—The history often points to some form of chronic irritation rather than a single trauma, therefore carious teeth and chronic ulcers are often important etiological factors. Men are attacked oftener than women and those past forty oftener than younger individuals.

Diagnosis.—The rapid growth and infiltration of adjacent tissues, the tendency to early ulceration and hemorrhages exhibited by these tumors even more so than by sarcomata enable the surgeon to differentiate them from tumors benign in character. While the secondary involvement of the lymphatic glands is an aid in differentiating these tumors from the sarcomata, nothing short of a thorough microscopical examination is exact. Such an examination should always be made because the prognosis in these tumors is even more gloomy than with the sarcomata.

Treatment.—The treatment should be practically the same as that for the sarcomata only more radical in that the submaxillary gland should be excised and the cervical lymph glands should be removed by a thorough dissection. The time of removal must be decided by the nature of the case.

In inoperable cases, however, Coley's fluid and the arsenical preparations are of absolutely no value.

Operations upon the Upper Jaw.—The nature of the operation is determined by the character and extent of the morbid growth, and often by the report of the pathologist at the time of operation. If the tumor is innocent, care should be taken to disfigure the face as little as possible, and to sacrifice no more of the bone than is absolutely necessary.

Very often, when the tumor is small and confined to a limited portion of the bone, it may be removed from within the mouth after dissecting up the cheek from its attachments.

If it is impossible to effect this by reason of its position and attachments, a tumor of considerable size may be sufficiently exposed, by means of an incision through the lip in the median line, carried into the nostril of the affected side alongside the septum nasi, and the cheek with the corresponding ala nasi is then dissected from the bone. When the growth is confined to the antrum—a polypus, for example—it may be reached and removed by means of this incision through the anterior wall of the antrum, or from within the mouth through the palatal process, without external incision.

When the growth is of great size, or when it belongs to the malignant class of tumors, nothing less than excision of the entire upper jaw should be undertaken.

S. D. Gross gives the credit of the first removal of the upper jaw to Dr. Jameson, of Baltimore, Md., who successfully performed the operation in 1820; but the honor is by other writers given to Gensoul, of Lyons, whose case occurred in 1827. Lizars, Liston, Syme, Mott, Dupuytren, Heath, and many other pioneers in surgery have repeatedly extirpated the upper jaw successfully, but the established position of the operation is, in great measure, due to important modifications suggested by Sir William Ferguson.

The special instruments required for excision of the upper jaw are strong angular bone forceps, tooth and lion forceps, a small strong saw, a wire saw, chisel and mallet, periosteal elevator, Paquelin cautery, and gag.

Preparation of the Patient.—In addition to the usual aseptic preparation of the operative field, it is wise to have the teeth put in good condition, though extraction of teeth from the affected jaw is not necessary or advisable. The mouth should be cleansed at regular intervals with some mild antiseptic solution and the nose should be sprayed. While such preparation may have a favorable influence on wound healing, it must be remembered that one of the greatest dangers of the operation is aspiration pneumonia due to the accumulation of blood in the pharynx during the anesthesia and that infection of the wound itself is seldom of any consequence. Realizing this, Kronlein, instead of using the anesthetic to the surgical stage, uses morphine gr. $\frac{1}{6}$–$\frac{1}{4}$ before the operation and only a few whiffs of ether during the operation, with surprisingly good results. This method combined with a thorough local anesthetization might be satisfactory in some selected cases.

Ether and the semi-recumbent posture, the Trendelenburg position, Rose's position, and whiskey to the point of insensibility, have all been tried and have all proven more or less unsatisfactory. The anesthetist is in the way if ether is used with a mask and blood flows into the pharynx in spite of plugging the posterior nares and very rapid work on the part of the operator. Crile introduced the method of giving ether vapor through tubes passing through the nose into the pharynx. This method, which is safe, is probably the most satisfactory method yet devised, since it enables the surgeon to keep blood from entering the pharynx and trachea by packing with gauze around the tubes. Another advantage is the fact that the anesthetist is not in the operative field.

Rectal anesthesia and the intravenous method of anesthesia have not been sufficiently developed for general use. If perfected, however, they will probably be used a great deal in this operation.

If Crile's method of anesthesia is to be used, then, after anesthetizing the patient in the usual way, the tubes are passed into the pharynx through the nostrils and connected by means of a Y connection to another tube leading to the vaporizer. Gauze is packed above the ends of the tubes in the pharynx in such a way as not to interfere with a free flow of the ether vapor. Packing should also be placed around the tubes in the posterior nares.

The Operation.—An incision is commenced at the inner canthus of the eye on the affected side and is carried vertically downward until it reaches the ala nasi, it is then curved around this and continued inward as far as the median line; a second incision, which is slightly curved with the convexity downward, is then made from a point over the most prominent part of the malar bone to the commencement of the first incision.

Hemorrhage can be largely controlled by an assistant whose duty it is to control by digital pressure both facial arteries where they cross the mandible. The angular, lateral nasal, and septal arteries are divided and should be caught in hemostats. Through the horizontal limb of the incision the periosteum covering the orbital plate of the superior maxilla should be raised from the bone as far back as the sphenomaxillary fissure while the contents of the orbital cavity are elevated and protected by a spatula. Now the triangular flap of tissue between the two incisions should be dissected up from the bone as rapidly as possible. In doing this the infraorbital artery and nerve are divided. Tension on the flap often stretches the infraorbital artery so that it can be grasped on the proximal side before division. The nasal process is best divided with strong bone forceps applied as shown in the accompanying illustration. Some sur-

geons preserve the nasal mucous membrane because the interference with speech and nasal breathing after the operation is not so great. Therefore if possible dissect the mucous membrane from the wall of the nose before applying the bone forceps. Then with the forceps divide the nasal process. Until the nasal process has been divided no blood should have entered the nose or mouth, since the dissection should only have bared the bone without dividing the mucous membrane along the alveolar process. Continuing the lower part of the first incision, the upper lip is now divided in the middle line and with a few rapid strokes of the knife the mucous membrane is divided along the alveolar process the full length of the bone. Any hemorrhage is controlled by sponge pressure while with a small saw or, better, with a wire saw passed through the sphenomaxillary fissure with a curved needle, the malar bone is divided along a line continuing the anterolateral direction of the sphenomaxillary fissure. Divide the nasal mucous membrane sagittally close to and parallel with the septum and likewise divide the mucous membrane covering the palatal process in the mouth and separate the soft palate from the bone by a transverse incision. Saw the palatal process after having extracted a tooth if any are in the saw line. Grasp the bone with lion-forceps and depress it. The remaining attachments are thus brought into view, and their division effected with the knife or forceps. The infraorbital nerve should be cleanly divided, and as much of the soft palate preserved as possible. The jaw having been taken away, any remains of the growth should be removed with the gouge, and roughened points cut off with bone forceps. Hemorrhage during the operation is usually trifling, in many cases not a ligature being required.

Preliminary ligation of the common or external carotid artery, even if only temporary, is in the author's

Fig. 3557.—Line of Incision in Excision of the Upper Jaw by External Flap. Fergusson's Method. (Erichsen.)

opinion hardly justifiable inasmuch as such a step adds to rather than lessens the shock. Of course in some few cases it is necessary to ligate the external carotid in order to control hemorrhage. If a ligature is applied to the external carotid artery it is better to apply it above rather than below the origin of the superior thyroid branch.

After the removal of the jaw all bleeding points that can be reached should be ligated, and the actual cautery applied to vessels beyond the reach of the ligature. The cavity left by the removal of the jaw should be dusted over with subiodide of bismuth and packed with gauze. The latter should be put in rather tightly in order to support the cheek and repress the tendency to oozing of blood. The ends of the gauze strips should be brought out through the nose.

The tegumentary flap is brought accurately into place, the wound closed with silkworm-gut sutures at the lip, and in the rest of its extent with fine catgut, horsehair, or silk sutures. After the second or third day the packing should be removed, and the cavity thoroughly cleansed daily with some antiseptic solution. The patient should sit up as soon as his condition will permit.

If the tumor is of a malignant nature the cervical lymph glands should be thoroughly removed by dis-

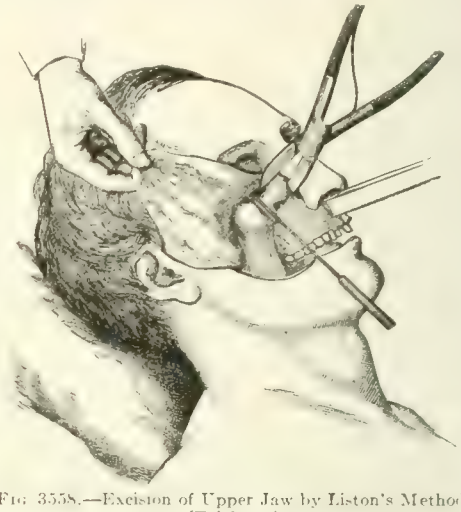

Fig. 3558.—Excision of Upper Jaw by Liston's Method (Erichsen.)

section at a later operation. It is hardly justifiable to attempt this operation at the same time the resection is done.

Results.—In 1,198 cases of complete resection of the upper jaw the operative mortality was 17.2 per cent. Pneumonia, shock, sepsis, meningitis, and hemorrhage were the principal causes of death.

The more recent statistics show a greater number of deaths as the result of the operation itself than the older ones. This is probably due to the fact that at the present time all operators do a much more radical operation and operate on cases that in the past would have been considered inoperable. The result of this is that while the immediate mortality is greater, the recurrence of malignant neoplasms is somewhat delayed.

In the practice of Prof. W. T. Briggs and the author, of thirty-eight cases of total resection of the upper and lower jaws (twenty-four by the former, fourteen by the latter) there have occurred only two deaths. One of these occurred as the result of an intestinal inflammation set up by the administration of ether per rectum, the other was due to shock, death occurring sixteen hours after operation.

In 1896 the author had the unusual experience of performing six resections of the jaws—two of the upper, four of the lower—in two weeks. All of these patients recovered from the operation.

Osteoplastic Section of the Upper Jaw.—This term applies to an operation devised by Langenbeck, in 1859, for the removal of tumors situated behind the upper jaw without involving that bone. Little change has been made in the operation since that time further than that Kocher and others have modified the skin incision so that the facial nerve is spared and the expression of the face little changed. The essential part of the operation consists of the division of the attachments of the jaw in such a manner

that the bone can be displaced downward or to the outer side sufficiently to expose tumors growing from the sphenoid or ethmoid bones, or from some of the fossæ between these bones and the palate bone. After removal of the tumor the jaw is replaced in its normal position, so that union of the divided bones will take place. The operation has been performed a number of times, with gratifying results, both in this country and in Europe.

Removal of Both Upper Jaws.—Excision of both upper jaws was first successfully performed by Heyfelder in 1844, since which time the operation has been occasionally repeated. It may be performed by carrying incisions from each commissure of the lips to the external angles of the eyes on both sides, and reflecting the flap, together with the nose, upon the forehead. The bony attachments of the jaws, the malar processes on each side, and the junctions of the bone with the nasal bones and vomer, are divided with the saw and forceps. The bones are then grasped with lion-forceps and forcibly wrenched from their position.

Injuries and Diseases of the Lower Jaw.—The principal injuries and diseases of the lower jaw are dislocation and fracture, abscess, periostitis, necrosis, actinomycosis, arthritis of the temporomaxillary articulation, and the various kinds of tumors.

Dislocation of the Jaw.—This accident, not infrequent in middle age, is rarely met with in the extremes of life. It occurs more commonly in women than in men. Though in the majority of cases bilateral, the dislocation may be confined to one side. On account of the peculiar configuration of the joint, the displacement is almost invariable forward, though in rare instances it may be upward, backward, or outward. In such cases there is necessarily an accompanying fracture.

In the production of forward dislocation of the jaw, as in all other accidents of the kind, muscular action

Fig. 3559.—Dislocation of the Jaw.

plays an important part, though violence, applied either from without or within the mouth, is usually the immediate cause. The dislocation may be the result of muscular action alone, as when it occurs in yawning, vomiting, or immoderate laughter. Sometimes it occurs during a general convulsive seizure as in epilepsy. When the result of violence, the force is generally received upon the chin at a time when the mouth is stretched widely open. The accident is occasionally produced during operations performed within the mouth, as in extraction of teeth, taking an impression, the use of the laryngoscope, etc.

The mechanism of the dislocation is simple. When the mouth is widely opened, the condyle leaves the glenoid fossa proper and, carrying with it the interarticular menisens, rests upon the articular eminence. This relation of the bones is peculiarly favorable to the production of the accident, and the slightest violence applied to the chin, or a sudden spasmodic contraction of the muscles of the jaw—especially the external

Fig. 3560.—Dislocation of the Jaw.

pterygoid, the action of which pulls the condyle still further forward—is all that is necessary to cause the condyle to slip over the articular eminence and the dislocation is complete. As soon as the condyle has taken up its new position in the zygomatic fossa, the masseter, internal pterygoid and temporal muscles forcibly contract and thus fix the jaw in the position so characteristic of the accident. The capsular ligament is stretched but not often torn; the lateral ligament is tense, the temporal muscle is put on the stretch and occasionally some of its fibers are torn. As shown by Heath, the coronoid process seldom causes the fixation by resting against the malar bone, that it can do so, however, is shown by a specimen in the Musée Dupuytren to which Treves calls attention in his work on Applied Anatomy.

Signs and Symptoms.—When the dislocation is bilateral the symptoms are most marked. The mouth is stretched open to its widest extent and immovably fixed in that position, so that both deglutition and articulation are very much impaired. The chin is pushed forward, so that the lower teeth project beyond the upper. The saliva, which is increased in quantity, dribbles constantly from the mouth. Immediately in front of the ear there is a marked depression owing to the absence of the condylar process from the glenoid fossa. A prominence above the zygoma, caused by contraction of the temporal muscle, is usually present.

In the unilateral form of dislocation, the symptoms are not so manifest, and may be so little marked as even to be overlooked. The mouth is held open but not near so widely as in the double form; the chin is usually directed to the side opposite the displacement, the parallelism of the teeth is lost and speech and deglutition are interfered with. The depression in front of the ear is perceptible on only one side.

When the displacement remains unreduced, the jaw after a time recovers its function to a great extent, the patient becoming able to close the lips and eventually to approximate the jaws sufficiently to masticate food. Speech and deglutition are fully restored, and much of the deformity overcome.

Subluxation.—Sir Astley Cooper described a condition of the temporomaxillary articulation which he called subluxation of the jaw, in which the condyle slips before the interarticular cartilage so that the mouth cannot be at once closed. The accident gen-

erally occurs in delicate persons whose ligaments and muscles are greatly relaxed. The exciting causes are yawning, biting upon some hard substance, etc. Usually the subject of the accident is able to overcome the trouble by making a lateral movement of the jaw, or by pressing the chin upward. The reduction is announced by an audible snap. In order to prevent continued recurrences, it is sometimes necessary to expose the meniscus and to attach it to the capsule of the joint with sutures.

Congenital Dislocation.—Mr. R. W. Smith was the first to call attention to congenital dislocation of the jaw, of which a small number of cases have been reported. The condition is characterized by great deformity, the lower jaw being atrophied to such a degree that the upper teeth project beyond the lower. This form of dislocation is invariably unilateral.

Treatment.—Reduction of dislocation of the jaw is usually easily accomplished. The force is to be applied so as to depress the angle of the jaw while the chin is raised toward the upper jaw. This maneuver, however accomplished, has the effect of depressing the displaced condyle below the level of the eminentia articularis, so that the muscles of mastication may draw it back into the glenoid fossa.

The usual method is as follows: The surgeon stands in front of the patient, who is seated in a chair or upon the floor, with his head thrown back and supported. The operator, having wrapped the thumbs with a towel or bandage to protect them, introduces them into the mouth and carries them back to the ramus on each side, at the same time grasping the body of the bone with the fingers. Pressure with the thumbs upon the teeth is then made downward and backward, while the chin is forcibly elevated by the fingers, and the condyle having by this movement been liberated, is suddenly drawn back into the glenoid fossa by the contraction of the muscles.

Occasionally it may be expedient to reduce one side at a time, care being taken that the condyle first reduced does not, while the other is being manipulated, slip out again.

When the dislocation is unilateral, efforts at reduction should be applied only to the affected side.

Another method, especially applicable to cases in which the above-described treatment has failed, consists in the employment of wedges of cork, soft pieces of wood, or the handles of case-knives placed far back upon the teeth between the jaws. The surgeon, standing behind the patient, draws the chin forcibly upward so as to make the jaw act as a lever upon the wedges as fulcrums; the condyles are thus forced below the level of the articular eminence and readily slip back in place.

In Nélaton's method the force is brought to bear directly upon the coronoid processes. The operator, standing in front of the patient, grasps the back of the head on each side by the outstretched fingers, and endeavors, with his thumbs pressing against the coronoid processes, to press the condyles in place. According to Stimson, this method is more efficacious if an assistant depresses still further the chin of the patient in order to relax the ligaments, while the operator makes backward pressure.

When the dislocation has been allowed to remain unreduced for any length of time, the reduction becomes more difficult. Reduction has been accomplished, however, at as late a period as the fourth month. The process employed for the reduction of ancient dislocations is the same as described above, though an anesthetic may be required, as much greater force is necessary in order to break up adhesions.

Recurrent dislocation of the jaw is seldom met with. It depends upon the existence of a rent in the capsule, or some change in the form of the eminentia articularis, or an unusual laxity of the ligaments.

The treatment after reduction is simple, the object being to limit the movements of the jaw for a week or ten days. The chin should be fixed by a bandage and talking and mastication of food prohibited, the patient being fed upon liquid diet for a number of days.

To prevent displacement in persons who are subject to recurring dislocations, the chin should be supported by a small silk cap held in place by elastic straps passing over the head or attached to a skull-cap. This apparatus should be worn until the tendency to dislocation no longer exists.

Fracture of the Lower Jaw.—This is the most common fracture of the bones of the face. It occurs oftener in males, especially during the third and fourth decades of life. Blows upon the jaws, falls from great heights, and kicks from horses may be mentioned as the most common causes of the accident. Partial fractures, in which portions of the alveolar process are torn loose from the body of the bone, occasionally occur from extraction of teeth.

When the alveolar border is involved in the fracture, as it nearly always is, the mucous membrane gives way and the fracture is, therefore, compound. It is the exception, however, for a wound in the skin to communicate with the fracture. Not infrequently the bone is broken in two or more places and one case is on record in which there were five distinct lines of fracture, but comminuted fracture, except as the result of gunshot wound, is rare.

The jaw may be broken in any part of its extent, though, on account of its more exposed position, the body of the bone is the part most liable to the accident. When the body of the bone is broken, the line of fracture is generally in the vicinity of the canine teeth, where the jaw is naturally weakest, owing to the depth of the socket of that tooth and the proximity of the mental foramen. The ramus of the jaw is less often fractured on account of the direction of its axis, its great strength, and its protected position. Fractures through the symphysis are very uncommon because of the great thickness of that part of the bone. The coronoid process may occasionally be broken by extreme violence directly applied. A fracture of the neck of the condyle is extremely rare.

When the jaw is broken near the symphysis, the line of fracture is almost vertical, when near the angle of the jaw, the line of fracture is usually oblique, running from behind the last molar backward and downward, and, as pointed out by Malgaigne, the fracture occurs at the expense of the internal plate of the anterior fragment and the external plate of the posterior fragment.

Signs and Symptoms.—These are usually very obvious. The special signs of fracture—crepitus, preternatural mobility, and deformity—are all well marked.

Pain, which is greatly increased by movements of the jaw, is invariably present. Irregularity in the line of the teeth is readily detected by the finger introduced in the mouth. The teeth which adjoin the fracture are loosened, often detached, and, in a case reported by Erichsen, a tooth became separated and lodged between the fragments. The mucous membrane is nearly always torn, giving rise to more or less hemorrhage. Saliva is secreted in excessive quantity, and, mingling with the discharges of the wound, decomposes, and gives rise to an offensive fetor most difficult to control, even by the most careful attention. When the fracture is double, the bone being broken on each side of the symphysis, the central fragment is displaced very much downward by the depressor muscles.

In single fractures near the symphysis the displacement of the fragment is usually great, while it is less the nearer the fracture is placed to the angle of the jaw. Fractures of the ramus are attended with very little displacement, owing to that part of the bone being covered and protected by the masseter and internal pterygoid muscles.

In fractures of the neck of the condyle the symptoms are pain, crepitation, diminished mobility, failure of the condyle to share in the movements of the jaw and irregularity in the region of the condyle, which is due to the fact that the external pterygoid muscle draws the condyle forward. As pointed out by Ribes, the chin deviates toward the injured side.

Considerable inflammation generally follows fractures of the jaw—the face and neck are swollen and infiltrated, and not infrequently troublesome abscesses form.

As possible complications of fractures of the lower jaw may be mentioned, hemorrhage from wound of the inferior dental artery, temporary sensory paralysis of the lower lip and integument of the chin from laceration or contusion of the inferior dental nerve, necrosis, salivary fistula, and abscesses.

Simple fractures of the lower jaw heal in from thirty to forty days. Instances of non-union are extremely rare. The prognosis, as regards both deformity and the restoration of function, is good, for even in cases in which it has been impossible to obtain perfect apposition of the fragments, and union with some deformity has taken place, ultimately the deformity almost disappears, and but little evidence of the fracture may be detected.

Treatment.—Reduction in simple fracture is usually easily accomplished by conjoint manipulation, acting within the mouth upon the teeth and externally upon the border of the jaw.

When the line of fracture is very oblique and the fragments overlap and become locked, reduction is occasionally difficult. In such cases it may be necessary to expose the bone at the seat of fracture, and make a resection of the fragments before proper apposition of the segments can be accomplished.

When the fracture is simple and the tendency to displacement is slight, in many cases it is only necessary to maintain the fragments in place after reduction by means of a four-tailed bandage, which is so adjusted as to fix the lower jaw against the upper, thus utilizing the latter as a splint. In addition to this bandage or the other forms of bandage used for this purpose, as Barton's figure-of-eight, or Gibson's bandage, a cup-shaped splint of pasteboard or gutta-percha moulded to the chin, may sometimes be advantageously used. During the process of repair mastication and talking should be forbidden. Nourishment in fluid form should be administered, either by being sucked into the mouth between the teeth, or through a tube carried into the mouth behind the last molar tooth.

This simple method of treatment is most effectual when the fracture is uncomplicated.

In regard to the management of loosened teeth, the idea formerly held, that they should be extracted as foreign bodies is no longer entertained; they should be allowed to remain, as they soon contract new adhesions and become as firm as before. It may even be advisable to tie them with wire or silk to adjacent teeth, until they have contracted new adhesions.

When the fracture is comminuted, or the tendency to displacement is very great on account of the obliquity of the line of fracture, this simple plan of treatment will prove ineffectual, and recourse must be had to one of the numerous ingenious mechanical supports that have been devised for such cases.

The old method of binding the teeth of the fragments together with wire or thread is objectionable, from the fact that in many cases the teeth soon become loosened by the strain thus brought to bear upon them and no longer afford adequate support. If, however, the teeth are all strong and the tendency to displacement is not too great, then wires applied so as to include several teeth on each side of the line of fracture and connected to teeth in the upper jaw so as to distribute the strain, especially if additional support is given by means of a Barton bandage reinforced with starch or plaster of Paris, may suffice to hold the fragments in apposition until union has taken place. Lohr's clamps, based on the same principle as wiring, may be used under similar conditions.

An ingenious contrivance for wiring the teeth together, which in skilful hands is capable of achieving a certain amount of success, is Hammond's wire splint, which consists of a frame of strong iron wire made to surround the teeth, to a number of which it is fastened by smaller pieces of wire carried between the teeth. To insure accurate adjustment, the wire frame should be shaped upon a plaster cast of the teeth.

Various forms of interdental splints, made of guttapercha, vulcanite, or metal, and moulded to fit over the teeth for some distance on each side of the

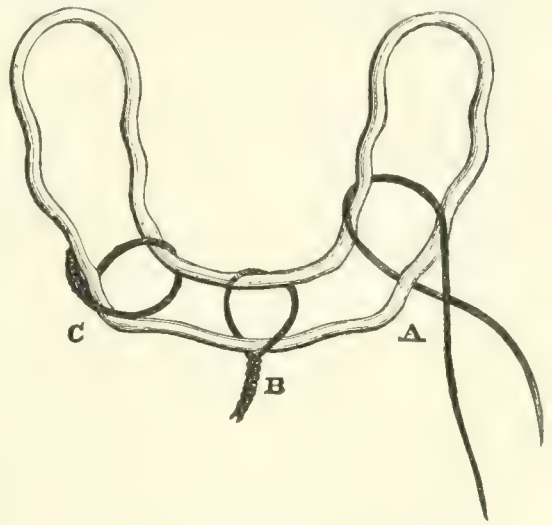

Fig. 3561.—Hammond's Wire Splint. (From Health.)

fracture, are sometimes used. They are either intended to act as a lateral support while the lower jaw is firmly held against the upper, or they are fastened to the teeth or the bone by means of screws or metal wires, or they may be attached to an outside support by means of rods passing from the mouth to the outside.

Any one of the various forms of these splints may be used. That of Kingsley answers the purpose admirably. It is provided with lateral arms of wire which are held in position by a strap passing around the neck. A bandage passed under the chin and around the wires adds to its efficiency. There are many other types of interdental splint. The surgeon should thoroughly familiarize himself with the making and fitting of one type of splint and use that to the exclusion of all others so far as possible. Many surgeons rely entirely on dentists to apply interdental splints when the nature of the fracture demands such apparatus. It would be beyond the scope of this article to describe the various types of interdental splints and to go into a discussion of their relative merits. For this the reader must consult some of the standard works on dental surgery.

When the fracture is very difficult of management, as for example, when the bone is broken in two places, and the middle fragment is drawn downward and cannot be maintained in place by any of the above methods, or when the fragments overlap each other and are difficult to reduce, then a more rational and certain mode of treatment consists in exposing the bone at the seat of fracture, preferably from the oral side, drilling holes well below the teeth in the fragments on each side of the fracture and wiring the fragments

firmly together. König has used this method, which was first advocated by H. Thomas of Liverpool, with satisfaction for many years. When there is a failure of union or a pseudarthrosis, the ends of the fragments can be freshened and the bones wired.

In fractures of the ramus of the jaw the displacement is usually slight. After reduction, the teeth of the upper and lower jaws can be wired together and additional security obtained by the application of a Barton bandage reinforced with starch or plaster of Paris.

In reducing fractures of the neck of the condylar process, the surgeon locates the small upper fragment with his finger in the patient's mouth, makes backward pressure on this, while with the other hand the jaw is forced upward so as to interlock the fragments. If reduction is obtained by this or any other method, it is manifestly difficult, in many cases impossible, to retain the fragments in proper position. After reduction the jaw is immobilized with a bandage.

Alveolar Abscess.—The etiology, symptoms, course, and termination of acute alveolar abscess of the lower jaw differ in no respect from those of the same affection of the upper jaw, described in a preceding section of this article.

Chronic Alveolar Abscess.—Etiology.—Bacterial invasion is invited by injury, by the irritation of carious teeth, or the degeneration of a dentigerous cyst.

Symptoms.—There is slow, steady enlargement of the bone, sometimes accompanied by a dull, aching pain, though more frequently without any pain. The accumulation of pus occurs between the osseous plates of the jaw, but it is seldom that the expansion is so great that the peculiar egg-shell crackling can be elicited by pressure. The slow increase in the size of the bone, and the firm consistence of swelling in chronic abscess have, in a number of cases, led surgeons to remove portions of the jaw under the impression that they were dealing with solid tumors. However, the history of the case and the presence of pus at the operation should enable the surgeon to make a diagnosis.

Treatment.—The treatment of chronic abscess is to evacuate its contents. This may usually be easily accomplished from within the mouth; but it is sometimes necessary to expose the swelling by raising a flap of skin, and then to apply the trephine to the bone.

Acute Periostitis.—The etiology is the same as in periostitis of the upper jaw.

Symptoms.—Swelling of the gums and the side of the face, severe throbbing pain in the part, worse at night; the teeth are raised in their sockets, and when pressed upon the most exquisite pain is elicited. Very frequently from reflex irritation there is spasmodic closure of the jaw. The swelling often extends into the neck, leading to a brawny infiltration of the tissues, and, when pus forms, the abscess generally points beneath the jaw.

Treatment.—If the condition is recognized early, active treatment—such as extraction of carious teeth, free incisions of the gums, and hot fomentations by holding hot water in the mouth, may prevent the formation of pus. When the process has become suppurative, the earlier the pus is evacuated the better.

When practicable the opening should be made from within the mouth, but generally the evacuation can be better accomplished by external incision, as, aside from the fact that the abscess most frequently points in the neck, better drainage is thus afforded. Detergent injections into the cavity should be constantly employed. If necrosis occurs complete separation of the dead part must be awaited before removing it.

Chronic periostitis is usually the result of syphilis. It is almost painless in its course, and manifests itself in the nodes which appear upon the alveolar border. It differs from chronic periostitis of the upper jaw only in that necrosis is more prone to occur. This form of periostitis yields readily to large doses of iodide of potassium.

Actinomycosis.—This disease, chronic in nature and caused by microorganisms belonging to the class of actinomycetes or ray fungus, usually manifests itself in the lower jaw by the formation of hard granulomatous nodules which have a tendency to soften, break down, and form sinuses which discharge a greasy, gritty, dark-colored secretion which often contains the characteristic "iodoform" granules. Its tendency is to spread from the primary atrium to adjacent or even remote tissues.

Etiology.—The ray fungus is found in grain, straw, and hay, consequently the disease is found oftener among grooms, bakers, millers, and in persons in the habit of chewing straw or grain. Lord found an organism having the morphology and staining reaction of the ray fungus in both smear preparations and serial sections of carious teeth. None of these patients had yet developed actinomycosis. Experiment has also shown that intraperitoneal injections of the contents of carious teeth produce omental tumors histologically identical with actinomycotic tissue. At present, however, carious teeth seem to be the cause rather than the effect of ray fungus invasion.

Signs and Symptoms.—There is usually an absence of fever and pain. The former occurs whenever there is a secondary infection with pyogenic organisms. Should the muscles of mastication become involved by extension of the process, as is sometimes the case, trismus may develop.

If the case is seen early there may be present simply a thickening of the gums or alveolar process. Since at first some tenderness is present the condition might easily be mistaken for an ordinary gumboil, a beginning alveolar periostitis, or a gumma. Later however, as the disease spreads, the bone becomes involved, the characteristic nodules develop over the body or angle of the jaw, the skin becomes discolored, abscesses form and break down with resulting fistulæ discharging a secretion in which the ray fungus may often be found though sometimes repeated microscopic examinations are necessary. Should the disease begin at the root of a carious tooth, however, the bone plates may be separated by the growth of the granulomatous tissue, leading to the formation of a tumor mass which might easily be mistaken for a cyst or solid tumor.

Treatment.—Incision, followed by a thorough curettage of the granulomatous and cicatricial tissue, after which the cavity is cauterized with a strong solution of zinc chloride, often produces a cure. The patient should be given iodide of potassium in doses of twenty to thirty grains after each meal. If the sinuses persist the Röntgen ray will often hasten the closure. If, in spite of the above outlined treatment, the process extends, if the muscles of mastication or other important tissues become involved, then nothing short of resection of the diseased portion of the jaw will suffice.

Necrosis.—This is more frequently met with in the lower than in the upper jaw, a fact most likely due to the greater vascularity of the latter and the more exposed position of the former. Necrosis may be complete, involving the entire thickness of the bone, or partial, as when it is limited to the alveolar process. It happens quite frequently that the external plate of the alveolar process becomes necrotic and is removed, while the internal plate remains intact and serves as an adequate support for the teeth.

Etiology.—Osteomyelitis occasionally causes a severe and rapid necrosis of the lower jaw which is often fatal in its termination. Necrosis of the lower jaw occasionally develops in the course of locomotor ataxia in which case it is due to some trophic disturbance. Partial necrosis often follows severe injuries. It

sometimes occurs in children upon the subsidence of the exanthematous fevers, especially scarlatina and smallpox. A peculiarity that has been observed in this form of necrosis is the symmetrical manner in which it affects the bone. In these cases the disease is generally limited to the alveolar process. Necrosis of the jaws from severe mercurial salivation was formerly a common occurrence, when in the treatment of syphilis or other diseases it was thought necessary to induce ptyalism in order to obtain the best effects of mercury. Many supposed cases of this kind in children, however, really owed their origin to tuberculosis, to cancrum oris, or to the poisonous effects of an exanthem. Fortunately, nowadays, necrosis as the effect of the abuse of mercury is rarely seen. The commonest cause of necrosis, however, is unchecked suppurative periostitis, in which the accumulation of pus separates the periosteum from the bone, and in this way cuts off the vascular supply. Death of the bone ensues very rapidly, often in a few hours, after the establishment of the suppurative process.

Signs and Symptoms.—The signs and symptoms of impending necrosis are severe pain, increased heat in the part, and rapid swelling of the gums and cheek. At this stage much may be done to arrest the death of the bone, or at least to limit the destructive process, by free incision of the gums, the extraction of carious teeth, hot fomentations, etc.

After necrosis has been established the pus finds an outlet by the side of loosened teeth, or wells up between the bone and the gum, which, during the process, become separated from each other; or it may burrow its way through the soft tissues to points beneath the body and near the angle of the jaw, where it points and is evacuated either spontaneously or by the surgeon. The discharge has the characteristic fetor of pus from dead bone, and in consequence of its constant entrance into the stomach, digestion is seriously interfered with. A probe introduced through a fistulous orifice readily comes in contact with denuded bone.

Treatment.—This consists, as in necrosis of the long bones, in the removal of the sequestrum, which, however, should never be undertaken until the separation of the dead from the living bone has taken place. It is especially important that this rule be observed in children before the permanent teeth have made their appearance, as a premature operation may not only seriously damage surrounding healthy bone, but also prevent the eruption of teeth that might otherwise have been saved.

If there are no external openings, and the ends of dead and detached fragments of bone project into the mouth, they may frequently be removed with the fingers or the forceps, only a small incision being required to enlarge the opening in the mucous membrane.

When the sequestrum is too large to be removed entire, it should be divided with bone forceps into two or more pieces, which can be taken away separately.

If at all practicable, the extraction of dead bone should be invariably effected through the mouth; but when the disease is extensive and a number of fistulous openings exist or when it is impossible to operate within the mouth on account of the fixity of the jaw, the sequestrum may be reached and removed by an external incision so placed as to avoid disfiguration of the face as much as possible.

Phosphorus Necrosis.—The attention of the profession was first called to this form of necrosis by Lorinzer in 1845. It differs from the ordinary necrosis in its etiology and pathology.

Etiology.—Inhalation of the fumes of phosphorus, especially the yellow or white form, is the principal cause of this disease, consequently it is found among workers in match factories and other industries in which yellow phosphorus is used. The red or amorphous phosphorus is not dangerous unless contaminated with the yellow form.

In many countries laws have been passed with good effect, in that the use of yellow phosphorus is prohibited, with a consequent elimination of this disease; but little has been done along these lines in most of the States of the Union.

Whether the fumes act locally through carious teeth, or whether it is a systemic condition with local manifestations has never been satisfactorily determined. The fact, however, that dental caries is usually present, that bacterial infection, which is a necessary concomitant to phosphorus necrosis, is present in carious teeth, that other bones are not involved, and that the pathological changes in other organs are not those of phosphorus poisoning, lead one to believe in the local rather than the systemic origin.

Pathology.—At first there is a deposit of bone in the interior of the jaw, later there ensues an absorption of the bone. This latter process necessarily leads to brittleness. At the same time, the periosteum, as it is slowly separated from the underlying bone, produces an osteophytic deposit, especially upon the lower side of the jaw. There is likewise a characteristic pumice-like deposit upon the sequestra.

Symptoms.—The approach of the disease is very insidious, the symptoms at first being mild and hardly noticeable. Toothache is probably the commonest initial symptom. As the morbid process advances all the symptoms are manifested in a most marked and exaggerated manner. The pain is excruciating, the swelling is very great, not confining itself to the immediate seat of the disease, but involving the side of the face and head; the discharge is profuse and very offensive; numerous abscesses form and open externally, forming fistulæ through which the probe can be made to touch dead bone. The health of the patient rapidly gives way, owing to the quantity of fetid pus necessarily swallowed, and to inability to eat sufficiently. Death frequently supervenes from exhaustion, amyloid degeneration of the abdominal organs, tuberculosis, or nephritis.

Treatment.—Prophylactic.—Until our legislatures, following in the footsteps of some foreign countries, prohibit the use of white or yellow phosphorus in the industries, and require regular monthly or bimonthly examinations of those employed where phosphorus in any form is used, the surgeon can only warn those exposed to the fumes of phosphorus who are suffering from dental caries or devitalizing constitutional diseases of the dangers of phosphorus poisoning and impress upon them the necessity of oral cleanliness and frequent examinations by a competent dentist.

Conservative.—Before detachment of the dead bone occurs, it is important to sustain the vital powers of the patient by the administration of tonics, stimulants, and nutritious food. Locally the mouth should be kept as free as possible of the discharge by the frequent use of antiseptic washes. If the case is seen early, such treatment, combined with thorough drainage of abscess cavities and removal of sequestra, will often produce a cure. Teleky, from observation of eleven cases in v. Eiselsberg's clinic, thinks that this conservative treatment obtains better results than does resection which, in his opinion, often precipitates an acute process.

Operative.—If the disease has progressed to the point where little improvement follows the conservative treatment, then resection, subperiosteal if possible, should be performed. Bogdanik extirpates, if possible, the entire lower jaw and claims much better results than with partial resection. In partial resections there often develops a necrosis in the remaining bone.

Tumors of the Lower Jaw.—Cysts, central myeloid sarcoma, carcinoma, and fibroma are more commonly observed in the lower than in the upper jaw.

Fibroma.—This is a growth of frequent occurrence in the lower jaw. As in the upper jaw, it may be either of endosteal or periosteal origin. Nothing definite is known of its causation.

The endosteal form of tumor, as it increases in size, leads to expansion and thinning of the two plates of the jaw bone—the external to a greater extent than the internal—and finally the bone undergoes absorption.

The periosteal fibroma grows most frequently at the junction of the gums with the teeth, and is distinguished from the fibrous epulis only by its greater size.

Treatment.—If the disease is of long standing, the tumor very large, and the jaw more or less destroyed by the absorptive process, the growth should be removed with the segment of jaw involved. It may be possible to enucleate small tumors of this class. Advantage should always be taken of the fact that the external plate is principally involved to preserve the internal plate of bone, if practicable.

Chondroma.—These tumors are very rare in the lower jaw. They occur chiefly in children, and are remarkable for their slow, painless growth. When these neoplasms arise from the surface of the bone they are generally called ecchondromata, if from within the bone, enchondromata. They occasionally grow to immense size, not infrequently causing death by interference with the functions of respiration and deglutition. These growths only rarely consist of pure hyaline cartilage, generally consisting of a mixture of cartilage with fibrous, sarcomatous, or

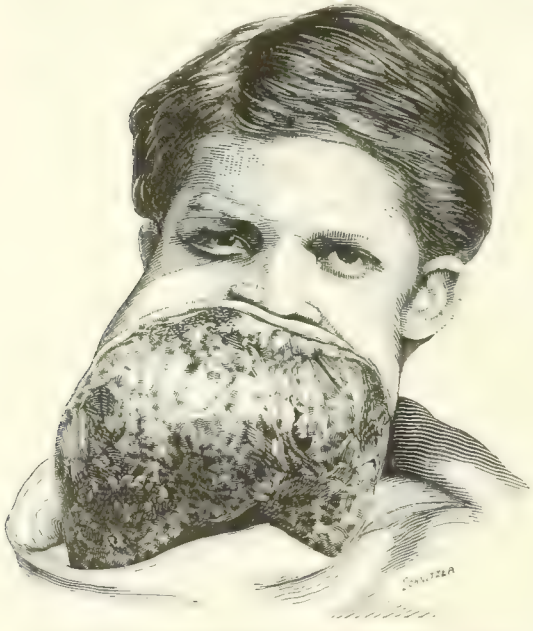

Fig. 3562.—Osteochondroma of the Lower Jaw. (From a photograph.)

bony tissue. Sometimes they are almost entirely transformed into bone, which is generally cancellous in structure, when they are appropriately termed osteochondromata.

The accompanying woodcuts are from photographs of a patient from whom Professor W. T. Briggs, in 1878, removed the entire lower jaw for a tumor of this class. The patient was a boy twelve years of age, and the tumor had been growing for ten years. The enormous mass protruded from the mouth and extended as far down as the chest. The mouth was entirely filled by the tumor, so that deglutition was very difficult and articulation imperfect. The health of the patient was only slightly impaired. The specimen measured six inches in diameter and weighed eight pounds.

As may be observed from the picture of the macerated specimen, more than half of the jaw bone had been absorbed. The second molar had been transported in the tumor half an inch above the alveolus.

Fig. 3563.—Macerated Specimen of Osteochondroma Removed by Prof. W. T. Briggs. (From a photograph.)

The extraordinary size of the tumor may be estimated by the fact that the mouth had been so greatly distended that it was necessary, in the operation, to excise eleven inches of the patient's lip.

Osteoma.—These tumors may be either cancellated or of the kind known as ivory exostoses.

The cancellated osteomata most likely originate from the conversion of chondromata into spongy osseous structure.

Ivory exostoses are frequently found near the angle of the jaw. Such tumors seldom reach very great size. They are as hard and compact as ivory, of painless, slow growth, and irregularly nodulated. These tumors may be removed by chiselling or gouging them out from the surface from which they spring. The probability of recurrence is small.

Sarcoma.—The general appearance, symptoms, course, and treatment of this class of tumors are identical with those of similar affections of the upper jaw, described more fully in another part of this article. Sarcomata of the lower jaw are encountered more frequently and reach a larger size than those of the upper jaw.

The tendency to recurrence is one of the chief characteristics of sarcomata, and, therefore, in operations for their removal it should be the invariable rule to make sections through sound bone at some distance from the tumor.

Carcinoma.—This occurs most frequently in old age, though it may occasionally appear in early life. The principal features of epithelial growths are rapid destruction of bone, tendency to form fungating masses that protrude into the mouth, glandular involvement, etc. Carcinomata are sometimes secondary to epithelial growths of the lower lip, the disease in such cases extending directly from the lip to the bone. It is hardly necessary to mention the fact that primary carcinoma of the bone itself is unknown, the process always starting in other tissues and involving the bone secondarily.

The nature, diagnosis, prognosis, and treatment of carcinomata of the lower and upper jaw are practically

the same, though the chances of non-recurrence after removal are greater in the former, owing to its more isolated position.

The rule in excising portions of the lower jaw should be to go as wide of the disease as possible and to remove all lymph glands which are or may become involved.

Odontoma.—Odontomata are solid or cystic tumors of the jaws. So far as is known, they owe their origin to a perverted growth of some part of the tooth follicle, the particular type of tumor being determined by the type of cell predominating in the neoplasm. Often several types of tissue are found in the same tumor.

Classification.—The classification of these tumors is anything but satisfactory. In this article, Scudder's modification of Bland-Sutton's classification is adopted.

1. Dental Root-cyst. (2) Dentigerous Cyst. (3) Compound or Composite Follicular Cyst. (4) Adamantine Epithelioma. (5) Hard Odontoma.

These tumors are essentially benign in character inasmuch as they show little tendency to recur if thoroughly removed, their growth is usually painless and slow though a rapidly filling dentigerous cyst or an adamantine epithelioma may increase in size so rapidly as to arouse suspicion of malignancy; metastases do not occur, there is little tendency to ulceration and hemorrhage, and cachexia is absent. The fact, however, that occasionally they grow rapidly, cause severe pain and in such cases produce a deformity as great as that resulting from malignant neoplasms, should lead the surgeon to exhaust every means at his disposal, such as a careful history, the Röntgen rays, exploratory puncture, and if necessary, a microscopic examination of tissues removed at operation, before removing large portions of the jaw unnecessarily if the growth is benign, or leaving parts of the neoplasm behind should it prove malignant.

Dental Root-cysts.—These occur in the upper jaw oftener than in the lower, usually in connection with the permanent teeth, especially the incisors and bicuspids. Aspiration obtains a clear straw-colored fluid unless there has occurred a secondary infection, which indeed is rather common since carious teeth seem to predispose to this form of cyst.

Treatment.—This consists in opening the cyst from within the mouth, removing the cyst wall so far as possible, cauterizing any portions of the cyst wall left behind, and packing the cavity with iodoform or plain gauze.

Dentigerous Cysts.—These occur oftener in the lower jaw, especially at the site of one of the wisdom teeth. Aspiration obtains a fluid which is not characteristic, since it may be clear, bloody, or purulent. The bony covering of the cyst wall may be thin and parchment-like; oftener, however, the bone thickens along with the growth of the cyst. At operation, a tooth, usually only partly developed, or parts of several teeth, may be found in the cyst wall or free in the cavity of the cyst, though an absence of a tooth does not exclude the diagnosis of dentigerous cyst.

Treatment.—The treatment is practically the same as that given for the dental root-cysts. Occasionally the cyst involves so much of the bone that it is necessary to perform an operation amounting to a partial resection.

Compound or Composite Follicular Cysts.—As the name signifies, these cysts are composed of several types of tissue, the predominance of no one type being fixed. Hence examination after removal may show cement, enamel, fibrous tissue, or dentine to predominate. Teeth are not found in the cyst.

These cysts occur oftener in the upper jaw and practically always after the permanent teeth have erupted. Puncture obtains a fluid very similar to that contained in the root-cysts, occasionally it is bloody or purulent. These cysts occasionally reach large dimensions.

Treatment.—Since this type of cyst will often recur unless thoroughly removed, it is very important to remove the entire cyst wall and to cauterize the cavity. In some cases it is necessary to resect part of the jaw in order to be sure that none of the cyst remains.

Fig. 3564.—Dentigerous Cyst of the Upper Jaw in a Girl Aged 19 Years. (Bloodgood, Am. Practice of Surgery.)

Adamantine Epithelioma.—Theoretically, the origin of this type of dental tumor is due to an overgrowth of the cells of the primary epithelial cord after that structure, having served its purpose, is detached from the enamel organ.

These growths occur oftener in females and in the lower jaw. The tumor mass may be solid, cystic, or partly solid and partly cystic. If the cyst opens spontaneously or is opened by the surgeon, its growth may cease, the tumor, however, remaining. Aspiration may be negative or it may obtain a clear or bloody or purulent fluid. These cysts often grow in connection with the dentigerous cyst.

Treatment.—Eradication of the growth should be thorough and yet conservative, in that if a bridge of bone can be left to support the jaw, that much should be spared, since if all the growth is removed, there is little tendency to recurrence. Often only a microscopic examination of parts of the tumor, together with the history and the operative findings can differentiate this form of neoplasm from carcinoma. There is no doubt in the author's mind, that many unnecessarily mutilating operations have been performed by surgeons in the belief that instead of dealing with a non-malignant tumor, they were dealing with a carcinoma.

Hard Odontomata.—These are due to an overgrowth of some part of the tooth, usually the root. While these tumors are usually solid, occasionally, owing to a breaking down in the interior because of some infection, they are hollow and so are hard to differentiate from those dental root-cysts in which the cyst wall has become calcified. They occur oftener in the lower jaw and in their growth tend to thin and

separate the bone plates so that crackling can be elicited. They seldom reach a large size.

Treatment.—If the bone plates have been largely absorbed by the growth of the tumor, it may be possible to remove the tumor by extracting the tooth to which it is attached. This, however, is usually impossible because other teeth interfere. In such cases it is necessary to remove the lateral or medial plate of bone and enucleate the tumor through the opening. The remaining cavity should be packed with plain or iodoform gauze.

Operations upon the Lower Jaw.—Excision of the lower jaw was first performed by Dr. W. H. Deaderick, of Tennessee, in 1810, although credit has usually been given to Dupuytren, whose case occurred in 1812. Dr. Deaderick's operation was undertaken for the removal of a large chondroma, and was entirely successful.

The preparation of the patient and the method of anesthetization should be the same as for operations on the upper jaw. The same care should be observed in making a correct diagnosis before or during the operation, since it is desirable to sacrifice as little of the bone as possible in benign tumors and to resect subperiosteally where the nature of the tumor will permit.

When the tumor grows from the alveolus, is not malignant, and does not involve the entire thickness of the jaw, it is often possible to remove it from within the mouth with strong bone forceps and gouge, without making a complete section of the bone. In such cases the hemorrhage is often profuse but can be controlled by sponge pressure and Horsley's bone wax.

If the tumor is large and occupies the body of the bone between the symphysis and angle, as is most frequently the case, excision of a segment of the jaw between those two points is generally required. Such an operation can be done from within the mouth, but is rather difficult, especially in cases in which the neoplasm has attained any volume. The greater ease and thoroughness with which the bone may be excised by the external operation more than counterbalances the advantage obtained by operating so as to avoid a scar.

The operation for removal of the jaw between the angle and symphysis is performed as follows: The patient is thoroughly anesthetized, his head raised somewhat, and an incision made along the lower border of the bone from the symphysis to the angle. This incision is made down to the bone except at the point where the facial vessels cross. The latter are exposed and divided between ligatures, after which the bone and tumor are thoroughly exposed to view by dissecting up the soft tissues. If the tumor is innocent the surgeon should ascertain at this stage of the operation whether it can be removed without sacrificing the entire thickness of the jaw. If feasible, the growth should be enucleated or gouged out of its bed, and the lower border of the jaw left intact. If excision is determined upon, the internal surface of the bone should be cleared of its attachments with knife and elevator, and after removal of any teeth in the lines of the future saw cuts, the bone should be divided with a wire saw. After hemorrhage is controlled the mucous membrane of the mouth should be united to that of the cheek with horsehair or catgut sutures and the defect packed with gauze. The skin is united with interrupted sutures of silk, silkworm-gut, or horsehair except at the most dependent part of the wound where the gauze protrudes.

If the growth necessitates the removal of the symphysis, a curvilinear incision is made along the lower border of the jaw from a point somewhat anterior to the facial artery of one side to a corresponding point on the other side, and through this incision the bone is bared and the growth removed as in the above described operation. Since, however, the attachments of the geniohyoid and geniohyoglossus muscles are necessarily divided, a strong ligature should be passed through the tongue by means of which it may be drawn out and prevented from falling back into the pharynx and causing suffocation, as has happened in a number of cases.

If the growth involves the ramus alone then that portion of the jaw may be removed through an incision along the posterior portion of the body and the lower part of the ramus, the steps of the operation being similar to those of the operations already described. However, there is great danger of injuring the parotid gland and the facial nerve, and unless the

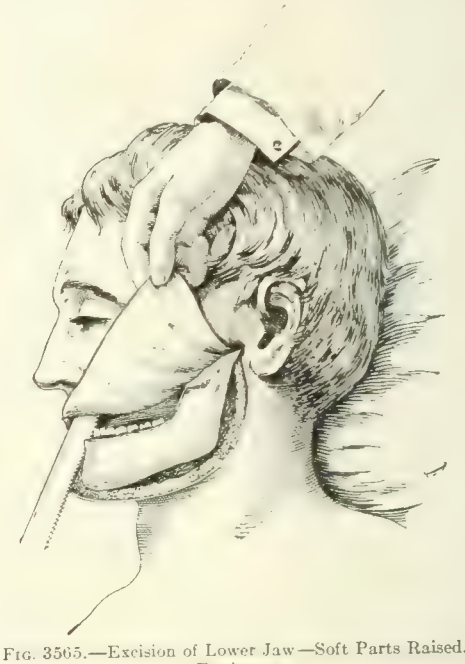

Fig. 3565.—Excision of Lower Jaw—Soft Parts Raised. (Erichsen.)

surgeon is prepared to use some prosthetic appliance which will prevent the tilting forward of the upper fragment, it is questionable if it is not the better practice to resect half of the mandible.

For the removal of half the jaw an incision should be made along the lower border of the jaw from the symphysis to the angle and from the angle along the posterior border of the ramus upward as far as the level of the lobe of the ear. The portion of the incision along the ramus as well as that part immediately over the facial vessels should divide only the skin. The facial vessels should be exposed and then divided between ligatures. A second incision passes vertically downward from the red of the lip to the anterior extremity of the first incision. If necessary divide the lip. Occasionally the incisions cannot be made in conformity with any given rules, but must be adapted to suit the case, and in exceptionally large tumors it may be necessary to take away large segments of the skin.

The flap of skin should be dissected from the surface of the tumor, an incisor tooth extracted at the point at which the section of the bone is to be made, and the jaw divided with a small saw. Before proceeding further, the tongue should be secured in a looped ligature. The bone should now be seized with the lion-forceps and drawn forcibly outward, in order that the attachments to the buccal surface of the bone may be divided. Especial pains should be taken to keep the edge of the knife directed against the bone, in order to

avoid wounding the submaxillary gland, the lingual nerve, and, nearer the articulation, the internal maxillary artery.

With the fragment still in the grasp of the forceps, the latter should be forcibly depressed so as to cause the coronoid process to start forward and thus permit of the division of the temporal muscle. The joint being exposed, the knife should be applied over it, by which the capsule is opened and the condyle released. In this step of the operation care should be taken not to twist the fragment of the jaw too far externally, as the internal maxillary artery may be thus pressed around

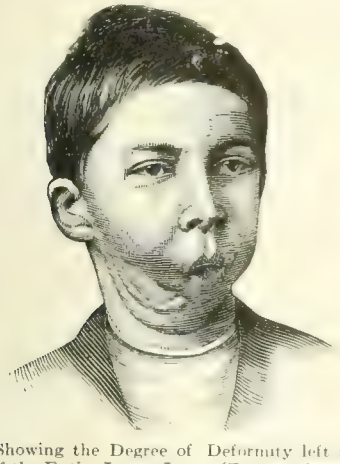

Fig. 3566.—Showing the Degree of Deformity left after the Removal of the Entire Lower Jaw. (From a photograph.)

to the front and wounded at the same time the capsule is opened. In very large tumors it is frequently impossible to reach the coronoid process. Under these circumstances the ramus should be divided as high up as possible, leaving the coronoid and condyloid processes to be dissected out after removal of the tumor. The few remaining attachments of the soft parts to the bone having been divided, the jaw is removed.

The close proximity of the internal maxillary artery to the neck of the condyle makes it very liable to be wounded, and it is therefore always necessary to observe the greatest caution in disengaging the condyloid process. When the artery is divided hemorrhage is very profuse, necessitating the immediate application of a ligature, or if on account of the great depth of the artery this cannot be done, the external carotid should be ligated.

If the growth necessitating resection of the jaw is malignant in nature, especially if carcinomatous, then in order to give the patient a greater chance of non-recurrence, it is necessary to excise the submaxillary gland and to remove by a thorough dissection all the gland-bearing tissue in the neck on the side corresponding to the growth. Oftentimes the surgeon can carry out this dissection at the time of resection; occasionally, however, the patient is in such a run-down condition from poor nutrition, pain, worry, etc., that it is better to postpone this operation until a later date which should not be longer than three weeks after the primary operation.

As in operations on the upper jaw, the mouth should be frequently cleansed with some antiseptic solution and the patient should sit up as soon as his condition will permit.

Results.—The immediate mortality of the operation of complete excision of the lower jaw is not over fifteen per cent. Pneumonia, shock, sepsis, meningitis, and hemorrhage are the principle causes of death.

Prosthesis after Resection of the Lower Jaw.—The various prosthetic appliances for preventing deformity and concomitant inconveniences are ingenious in the extreme and in many instances have obtained remarkable results. As a usual thing, the application of the appliance requires the skill of the dentist to aid the surgeon. Martin's "Prothèse immédiate" is more than likely the most practicable. A description of Martin's method will suffice, since other methods such as Bönnecken's, Partsch's, and Stoppany's, are along similar lines.

Martin's method consists in attaching a gutta-percha splint which is provided with lateral projecting metal plates, to the stumps of the bone, by means of nails and screws. The gutta-percha splint can be shaped accurately at the time of operation to meet the existing conditions. The provisional apparatus gives the necessary support during the period of wound repair, and is supplied with a system of channels that provide adequately for drainage and cleansing.

After cicatrization has become complete, the appliance is removed and a permanent artificial piece, preferably constructed of metal and provided with teeth, is inserted. This plate can be removed at any time in order to be cleansed. The results of this method of treatment in a number of reported cases have been all that could be asked.

While this ingenious method of rectifying and correcting the results of resection has much to commend it, it should be remembered that even after extensive resections of portions of the lower jaw, nature in its process of healing, accomplishes much that obviates the extensive deformity and functional troubles.

Closure of the jaws may exist in one of two forms, viz., temporary or spasmodic, and permanent or organic.

Spasmodic Closure of the Jaws.—This condition is most frequently due to firm contraction of the masticatory muscles, superinduced by severe or prolonged irritation of branches of the third division of the fifth pair of cranial nerves.

Etiology.—The most common cause of this condition is the difficulty that sometimes attends the eruption of the wisdom tooth, either from the fact of its being misplaced or because the space between the second molar tooth and the ramus of the jaw is insufficient. Among other causes may be mentioned hysteria, tetanus, alveolar abscess in the vicinity of the last two molars, peritonsillar abscess, actinomycosis, and necrosis of the jaws.

Treatment.—The treatment of this affection is obvious, viz., to remove the cause. When the condition arises from difficult eruption of the wisdom tooth, the patient should be thoroughly anesthetized and the jaws forcibly separated with a gag, in order that access may be had to the seat of trouble. If the wisdom tooth is presenting normally, it may be sufficient to incise the gum freely or to extract the tooth. Generally it is necessary to remove the second molar, in order that the wisdom tooth may have room to emerge. An alveolar or peritonsillar abscess should be freely opened, if the spasmodic affection is produced by such pathology.

Organic Closure of the Jaws.—This is a far more serious affection than the spasmodic form, the management of which often taxes the patience and skill of the surgeon, as well as the endurance of the unfortunate sufferer, to the utmost. It may be conveniently divided into two classes, namely, those arising from diseases of the temporomaxillary articulation, and those which have their origin in ulcerative action and cicatricial contraction in the perimaxillary tissues.

The diseases of the temporomaxillary articulation which may, by causing fibrous or osseous ankylosis, lead to permanent closure of the jaws, are acute and chronic arthritis.

Acute Arthritis.—This may follow mechanical injury for example, blows upon the side of the face, dislocations, or fractures into the joint—or it may supervene upon the exanthematous fevers in connection with diseases of the middle ear. It may arise in the course of an attack of gonorrhea, parotiditis, or an osteomyelitis of the lower jaw and it is hardly necessary to mention the fact that this joint occasionally suffers in acute rheumatism.

Symptoms.—The symptoms of acute arthritis of the temporomaxillary articulation are pain, redness, heat, swelling, and stiffness of the jaw, sometimes amounting to entire closure of the jaws. If suppuration occurs, the pus may escape through the external auditory meatus or by means of an opening in the overlying skin.

Treatment.—The treatment of this condition should be rest to the joint by causing the patient to abstain from mastication, counterirritation over the joint, hot fomentations, and the evacuation of the pus if suppuration occurs. Internally larger doses of sodium salicylate should be administered. If the pain is severe, some of the coal-tar preparations or opium should be exhibited. If the arthritis is due to rheumatism the rheumatic phylacogen may be tried.

Chronic Rheumatic Arthritis.—This form of arthritis of the temporomaxillary joint is essentially a disease of old age, fortunately, however, rarely met with. It may affect one or both sides, but is more frequently unilateral.

Symptoms.—The symptoms are gradual enlargement of the condyle, which may often be plainly felt beneath the zygoma, pain on opening the mouth, and a peculiar creaking of the joint on moving the jaw, plainly perceptible to the patient. The neighboring lymphatic glands are enlarged. The face is distorted, the chin being inclined to the sound side when the disease is unilateral, carried prominently forward when bilateral. The pathological changes are the same as those of chronic arthritis of any other joint—the articular cartilage undergoes disintegration and absorption, the glenoid cavity is enlarged, the interarticular cartilage disappears, the eminentia articularis is leveled down so as to permit of partial dislocation, and the neck and head of the jaw are thickened and enlarged. The muscles are in a state of tonic contraction in the effort to keep the inflamed joint surfaces in contact, and, as a consequence, stiffness of the jaws is always present to a greater or lesser degree.

Treatment.—In the treatment of this disease little is to be hoped for from the action of medicines, though active counterirritation over the joint and the exhibition of increasing doses of the iodide of potassium have been recommended.

Ankylosis of the Jaw.—This is the result of arthritis and may be fibrous or osseous. No matter whether the disease is unilateral or bilateral, mastication is impossible.

If the ankylosis is unilateral, the deformity is usually present on the opposite side to the ankylosis. The diagnosis between the fibrous and osseous varieties can only be ascertained when the patient is under the influence of an anesthetic, and often not until the joint is exposed.

If fibrous, the adhesions may be broken up and the jaws gradually separated by means of a screw gag made for the purpose, or by levers and wedges introduced between the teeth to keep the jaws apart. The tendency of the parts to become fixed again renders the daily repetition of this process necessary for months, and even for years. Even with the most constant care on the part of the surgeon, and the fullest cooperation of the patient, the result is very seldom satisfactory, and at the present time is rarely resorted to, except as after-treatment to more radical operations.

In both fibrous ankylosis, in which so little is to be hoped for from mechanical treatment, and in osseous ankylosis, or synostosis, the method which promises the best results is the restoration of the usefulness of the old joint or the establishment of a false joint through the neck of the condyle, by means of a radical operation.

If the ankylosis is osseous it is probably better to divide the neck of the condyle, and by the interposition of fascia or muscular tissue, establish a joint at that point, rather than to attempt to separate the condyle from the glenoid cavity. If, however, the ankylosis is fibrous it is better to restore the usefulness of the joint rather than to establish a new one. The steps of the operation are practically the same for the two operations, except of course should the surgeon elect to make a false joint a division of the bone is necessary.

The operation is performed as follows: A vertical incision is commenced somewhat below the tubercle of the zygoma and in front of the temporal artery and is carried upward for two inches or more. Commencing at the point where the incision crosses the zygoma, the soft tissues are pushed downward and forward by means of the knife and blunt dissector until the joint is exposed. While the soft parts are held aside by means of a hook or retractor the joint is examined. If the ankylosis is fibrous, after dividing all adhesions, a strip of fascia about two inches long by an inch in width with its base downward is taken from the temporal region and its free extremity turned into the space between the condyle and the glenoid fossa. The base of this flap is prevented from retracting by two or three catgut sutures and likewise the part between the two bony surfaces is held in place by a few interrupted catgut sutures.

If the ankylosis is osseous, especially if the line of demarcation between the glenoid fossa and the condyle is not distinct, then it is safer, after thoroughly exposing the neck of the condyle, to divide and remove a portion of that structure with a wire saw or chisel and to insert a strip of fascia between the divided segments of bone. Should however, the coronoid process be involved in the ankylosis, then following the method of Lilienthal, the surgeon should make a second incision parallel to and over the zygoma down to the bone, resect that structure, turn it with the attached masseter muscle, the parotid gland, and facial nerve downward, thus obtaining an ample field to work in with a minimal amount of injury to important structures. After breaking down the ankylosis by means of the chisel, a strip of fascia should also be inserted here. Throughout the operation care must be taken to avoid injury to the parotid gland, the internal maxillary artery, and especially the facial nerve. If the zygomatic process is resected the fragments can be wired before closing the wound. The wound should be closed without drainage and motion should be commenced on the day following the operation.

Ankylosis Mandibulæ Spuria.—This is a condition in which the jaws are held firmly together owing to cicatricial bands in the adjacent tissues.

Etiology.—Extensive ulceration and sloughing of the buccal mucous membrane and the muscles of mastication, leading to the formation of cicatricial bands and closure of the jaws, is usually the result of cancrum oris, abscess of the molar teeth, mercurial ptyalism, necrosis of the jaw, typhoid, diphtheria, scarlatina, or syphilis.

Symptoms.—The principle symptom is the inability to open the jaw, but if the process commences in childhood and is allowed to exist for any length of time there is present a marked deformity owing to the lack of development of the lower jaw.

When the mucous membrane of the cheek, from one alveolus to the other, is involved, the cheek is

bound so closely to the jaw that all movements of the jaw are rendered impossible, and often the space between the teeth and the cheek is so limited as scarcely to admit the passage of a probe.

Frequently the new tissue has bone developed in it, which occasionally is present in the shape of an osseous bridge extending from one jaw to the other, thus serving to bind the bones even more closely together.

The condition of the patient is pitiable in the extreme, as food can be carried into the mouth only in fluid form, or by being rubbed against the teeth.

Treatment.—If the trouble arises in childhood, as is most frequently the case, treatment should be instituted as soon as possible in order that the development of the lower jaw may not be retarded. Attempts at relief of this condition by forcible separation of the jaws, have proved unsatisfactory, since as soon as the inflammation subsides, new cicatrices form to take the place of the old.

Various operations have been devised and practised for the relief of this condition with many failures and some successes.

Simple division of the cicatricial bands promises little, if any more, than does gradual dilatation, since, as healing takes place, new cicatricial tissue is formed at the seat of division. If however, the muscles are not too much involved, if healthy mucous membrane is obtainable, then division of the cicatrix and the insertion of strips of healthy mucous membrane taken from the floor of the mouth, the cheek, or the palate, as practised by Dr. John B. Murphy, will often result in a cure of the condition.

If possible, the anesthetic should be given through nasal tubes as previously suggested in this article, not only in order to keep the anesthetist out of the field of operation, but also in order to minimize the danger of clots passing into the trachea.

After the patient is thoroughly anesthetized, the mouth is dilated enough to give access to the cicatricial bands. The latter, held tense by firm pressure on the lower jaw, are divided with the knife, stroke by stroke, until the mouth can be freely and widely opened. This part of the operation is often very difficult. After division of all cicatricial bands, if the flap is to be taken from the palate or the floor of the mouth, teeth must be extracted in order to make room for it, after which the flap, which should be about two inches in length and from one-half to one inch in width, is raised from the palate or the floor of the mouth, as the case may be, inserted between the divided ends of the cicatricial bands and held in place with a few sutures which fasten it to the cicatricial bands and the cheek. In some cases Dr. Murphy uses the palatal and buccal flaps in the same operation.

If, as is sometimes the case, the cicatrix extends into the muscles of mastication on one side, it may be necessary to perform Esmarch's operation, modified according to the suggestion of Helferich.

Esmarch's operation is thus performed: "An incision is begun at the angle of the jaw and carried two inches along the lower border. A narrow strip of bone is then cleared on both sides up to the edge of the gum, a tooth drawn if necessary, the chain-saw passed around the bone through the incision, and the section made. The anterior fragment is then depressed and protruded through the wound, and a wedge-shaped piece, from one-third to one-half an inch in width at the widest part, cut off with cutting forceps." (Stimson, Manual of Operative Surgery.) This is the operation as originally performed. At present, however, by using the wire saw, it is unnecessary to protrude the anterior fragment of bone from the mouth. Helferich's modification consists in elevating a tongue-shaped segment of tissue from the deep surface of the masseter muscle with the base upward, carrying the free extremity of the flap of muscular tissue between the fragments of the divided bone, and attaching it by sutures to the internal pterygoid muscle. In doing this operation care must be taken not to injure the parotid gland posteriorly, the facial artery anteriorly, and the lingual nerve internally. Unless the division of bone is made further back than is usually the case, it is hardly possible to avoid division of the inferior dental nerve and artery.

In many cases the surgeon must rely entirely on his own ingenuity, in some cases nothing short of resection of a portion of the lower jaw will suffice in order to obtain an avenue into the stomach through which nourishment can enter.

C. S. Briggs.
W. T. Briggs.

Jecorin.—This is the name applied to a body which may be isolated from the liver, spleen, blood, and brain, possessing a reducing action upon copper oxide. It is soluble in ether, contains sulphur and phosphorus, and upon boiling with alkali and then cooling forms a gelatinous mass. It has been asserted that jecorin is a combination of lecithin and dextrose, but from the variable composition and divergent properties of the jecorin isolated by many investigators it is very probable that jecorin is only a mixture of several bodies among which sulphur-containing and phosphorus-containing substances occur.

F. P. U.

Jenner, Edward.—Born at Berkeley, County of Gloucester, England, on May 17, 1749. He began the study of medicine in Sodbury, near Bristol. Then, upon reaching the age of twenty-one, he went to London, where he became the favorite pupil of John Hunter, in whose house he resided for two years.

Fig. 3567.—Edward Jenner.

He obtained the degree of Doctor of Medicine from St. Andrews University, Scotland, in 1792, and soon afterward established himself in the practice of his profession at Berkeley, his native town. Jenner's discovery that vaccination with the virus of cowpox afforded effective protection against smallpox was made gradually during a period of several years. It was only in 1798 that he finally obtained satisfactory evidence that the method which he had so carefully and so persistently worked out, despite opposition of all sorts, was in reality what he believed it to be. The subsequent history of this remarkable discovery, which has already conferred immense benefit upon the human race and imperishable glory upon Jenner himself, cannot be told within the narrow limits of

this brief biographical notice. Suffice it to say that it was only during the first decade of the eighteenth century that vaccination as a protection against smallpox received anything like universal recognition. As a matter of fact, there are even to-day, in certain parts of the civilized world, groups of people who deny the virtues of the procedure. Jenner died on Jan. 25, 1823.

Jenner's first published work on vaccination bears the following title: "An Inquiry into the Causes and Effects of the Variolæ Vaccinæ, a disease discovered in some of the Western Counties of England, particularly Gloucestershire, and known by the name of the Cow-pox; with observations on the origin of the smallpox, and on inoculation," London, 1798; 3d edition, 1801. A. H. B.

Jenner, Sir William.—Born at Chatham, England, in 1815. He received his doctor's degree, in 1844, from the University College, in London. In 1852 he delivered the Gulstonian lectures in the College of Physicians; in 1853 he was chosen Assistant Physician to the London Fever Hospital; in 1854 he became physician to the University College Hospital; and in 1857 he was chosen Professor of Clinical Medicine in the same institution. In 1861 he was appointed physician extraordinary, and in 1862 physician in ordinary, to Queen Victoria. In 1863 he was appointed physician in ordinary to the Prince of Wales. In 1865 he was created a baronet. He died on Dec. 11, 1898.

Sir William Jenner was one of the most distinguished pathologists of his time. In 1847 he began, at the London Fever Hospital, investigations into cases of "continued" fever which enabled him finally to make the distinction between typhus and typhoid on which his reputation as a pathologist principally rests. As a consultant Sir William Jenner had a great reputation.

Of his published writings the following deserve to receive special mention: "On the Identity or Non-Identity of Typhoid, the Specific cause of Typhus and Relapsing Fevers," Medico-Chirurgical Transactions, 1850; "Diphtheria, its Symptoms and Treatment," 1860; "On Rickets"; and "On Tuberculosis."

A. H. B.

Jequirity.—See *Abrus Precatorius.*

Jersey.—See *Channel Islands.*

Jex-Blake, Sophia.—Born at Brighton, England, in January, 1840. She had received a remarkably fine education for a woman of that time, and desired to make a career for herself in educational work. In 1858 she became mathematical tutor at Queen's College, London. With a desire to increase her knowledge of the educational advantages accorded to women of various countries, she started on a tour of investigation. She came to America, and while in New York attended a series of lectures on medical subjects given by Dr. Elizabeth Blackwell. She was so impressed by these lectures that she went to Boston and began the study of medicine in 1866. Two years later, in 1868, she returned to England; and the following year, applied for permission to matriculate in medicine at the University of London. Since the character of this University did not permit women to study medicine within its walls, Miss Jex-Blake went to Edinburgh. Here she also met with difficulties, but finally succeeded in having a separate medical course for women established at the University. The diplomas granted, however, were not considered legal, so she and her women associates returned to London in 1874, where another struggle for medical recognition was begun. With her other women students, she succeeded in founding the London School of Medicine for Women, which was opened in October, 1874. Attendance at this school carried with it the privilege of attendance at the Royal Free Hospital. Desiring to have a diploma which would be recognized as legal, she went to Berne, Switzerland, and received her degree in 1877. In the meantime, in 1876, the British Parliament passed an Act, through which the women of England could obtain medical degrees at home. In 1878, after a struggle of ten years, Dr. Jex-Blake received a British diploma as Licentiate in Midwifery from King's College, London. In this same year, 1878, she began to practise medicine in Edinburgh, and established a Dispensary for Women and Children, which, in 1885 developed into a Cottage Hospital, and is now the Edinburgh Hospital and Dispensary for Women and Children. In 1886 the Edinburgh School of Medicine for Women was established through the efforts of Dr. Jex-Blake, and she was appointed dean and lecturer in midwifery. In 1894 this school was recognized as qualified for graduation of students in medicine by the University of Edinburgh.

Dr. Jex-Blake practised medicine until 1899, when she returned to her old home in Sussex. She died on January 7, 1912. She contributed many articles to medical literature. In 1867 she wrote two books on "American Schools and Colleges;" "Medical Women" reached its second edition in 1886. She also contributed many articles and papers on the Medical Education of Women, some of which were published in the Transactions of the Social Science Congress, Norwich, 1873, and a report on the same subject was given to the Chicago Conference in 1893. Her "Medical Women" was published in the Nineteenth Century Magazine for 1887, and "Medical Women in Fiction" in the same magazine in 1893. "Puerperal Fever" was one of her subjects, and her book on the "Care of Infants," reached its second edition in 1903.

E. L. J.

Jigger.—Chigoe.—A flea, *Dermatophilus penetrans*, that affects man and other animals. It burrows beneath the skin and causes irritation, pus formation, and ulceration. This insect is a native of Brazil but is now common in Africa and other countries. See *Insects, Parasitic.* A. S. P.

Joints, Anatomy of.—See *Arthrology.*

Joints, Diseases of.—See *Arthritis.*

Joints, Loose Bodies and Torn Cartilages in.—Loose Bodies.—The existence in a joint of a loose body was recognized first by Ambroise Paré in 1558, who removed one from the knee-joint. During the last century much consideration was given to the subject by many surgical writers. It appears that all freely movable joints may be the seat of loose bodies, but that the knee suffers by far the most frequently, and then the elbow. One loose body may be present in a joint, or very many. The size of these bodies varies greatly, sometimes reaching two or three centimeters.

The presence of a loose body in a joint is a sign of one or two things—trauma or disease. In some cases the method of formation is well understood, in others it is not clear. In joint tuberculosis the inflammation in the marrow beneath the joint cartilage may deprive the cartilage of its nutrition, and throw it off into the joint cavity as a loose body (Fig. 3568). Again, in the arthropathy of tabes (Charcot's joint), as the result of the morbid process in the marrow, pieces of bone and of cartilage may be separated and lie loose in the joint. A tuberculous sequestrum may be cast off into the

joint cavity, and so constitute a loose body. Rice bodies, small, smooth, slippery, hard bodies, often very many in number, are seen occasionally in tuber-

Fig. 3568.—Lifting off of Cartilage, due to Disease of the Subjacent Bone Marrow.

culous joints (Figs. 3569 and 3570). Collections of coagulated blood, foreign bodies, etc., would also come under the head of our definition. All these, strictly speaking, come under the head of loose bodies, but each forms a comparatively unimportant feature of a well-marked pathological process (with the exception of foreign bodies), and sinks into insignificance in comparison with the main disease. When we speak of a loose or movable body in a joint, we have before our mind a fairly well-defined picture, of which the offending body is the chief clinical feature.

A lipoma of the synovial membrane, pedunculated or not, or hypertrophied fringes of the membrane may cause symptoms hardly to be distinguished from those of a typical loose body. They are said to arise from chronic inflammatory or degenerative processes in the synovia, and may require operation for their removal. Their presence is not to be detected by the Röntgen rays, and must be diagnosed by the occurrence of sharp attacks of pain, not over the region of the semilunar cartilages, when the bodies are pinched between the bones, followed usually by an inflammatory reaction in the synovia. The differentiation between this form of loose body, and that about to be described, is not always possible until the joint is opened.

The typical loose body in a joint is composed of cartilage, or of cartilage and bone. It is found most often in the knee, and has received from the Germans the suggestive name of "Gelenkmaus" (joint mouse), on account of its slippery and elusive nature. The origin of these bodies has occasioned considerable discussion. Koenig and his disciples predicated a distinct causal disease called "osteochondritis dissecans." Barth denied this. Axhausen has imitated the formation of loose cartilaginous bodies by puncturing the knee-joint cartilages of dogs and of rabbits with an electric needle. We know that islands of cartilage can be formed in the synovial villi, and we assume that these may be separated, and may lie loose in the joint. Loose pieces of cartilage are often found in the joint cavity in cases of arthritis of Type II. (See the article on *Arthritis.*) It has been established fairly conclusively that a trauma may stand in direct causal relation to loose bodies. I have in my collection of specimens a disc of glistening white cartilage, smooth on one side and rather rough on the other, $22.5 \times 17.5 \times 10.5$ millimeters, removed from a man's knee-joint seven months after a severe trauma, which corresponds almost exactly to an area of rarefaction in the internal condyle of his femur, as shown by the skiagram. It is doubtful if the trauma in such a case always sets the body free immediately. Probably it causes a fracture through the cartilage and into the bone, and then the resulting inflammation in the marrow dissects off the partially loosened fragment whose nutrition has been impaired. This imitates the series of phenomena produced by Axhausen's electric needle. The same or a similar process is at the bottom of what the Germans call arthritis deformans—our Type II.

Complete tears of a fibrocartilage may give rise to a loose body in the knee. A complete tear, however, is much less frequent than a partial one. The torn fragment generally remains attached at one end.

In brief then the weight of evidence points to the synovial membrane, the articulating cartilages (with or without bone), or the fibrocartilages as the point of origin of these loose bodies. In the case of bodies from the articular cartilage or from the synovia the pathological process at the bottom of the trouble is essentially the same as that in Type II. of chronic arthritis (*q.v.*).

Fig. 3569.—Rice Bodies in their Capsule.

Symptomatology.—Loose bodies have been found snugly imbedded in the bone ends of joints of cadavers, presumably without ever having caused symptoms in

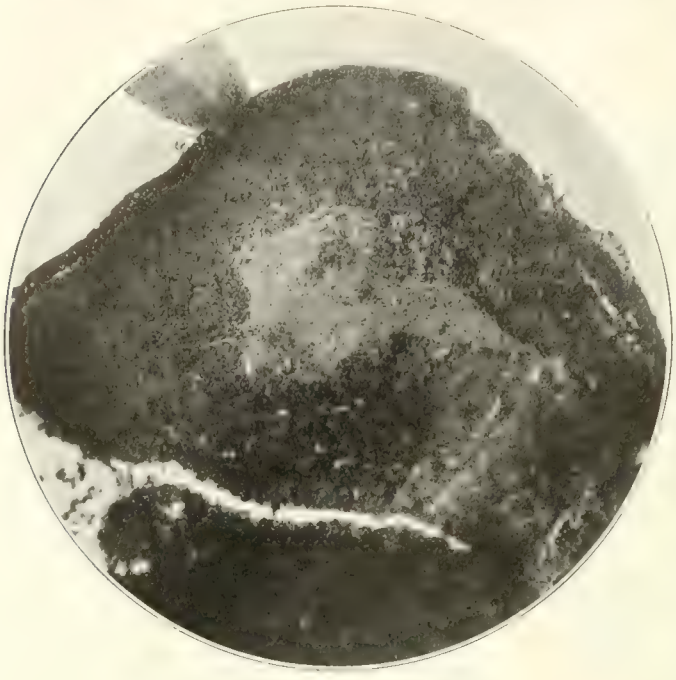

Fig. 3570.—Rice Body, Magnified.

life, but when they leave their place of formation, or are pinched between the bone ends at their place of formation, they are wont to give rise to a certain definite train of symptoms. The patient is seized with a sudden sharp pain in the joint, usually the knee, and the joint becomes locked, as a rule in semi-flexion. The locking is caused by the pinching of the body between the bone ends. By his own efforts, or with assistance, the patient usually dislodges the body, and motion returns in the articulation. An inflammation of the synovial membrane then ensues. The joint fills with fluid, and is more or less swollen, painful

Fig. 3571.—Loose Body Removed from the Knee-joint of an Adult. It consisted of cartilage with a thin layer of connective tissue on one side.

and restricted in function. The synovitis often subsides slowly, and the symptoms disappear until the cartilage is pinched again; or the loose body may keep up a constant irritation until it is removed. Probably the latter course is the more frequent. By careful palpation the offending body often can be felt slipping about in the joint. The pain in the attacks, if attacks there be, varies in its locality, therein differing from that caused by a torn semilunar.

Treatment.—The only treatment for a loose body is operative. If the body can be located exactly, the operation is usually quite simple. The patient may be of assistance in locating it. The operation should be done under general anesthesia, with all the strict asepsis of a major operation. The knee-joint permits of no margin of error in aseptic technique. Some surgeons recommend pinning the cartilage with a sterile needle, before the joint is opened. The operator may hold the body in place with his fingers, while the assistant makes a small incision over it, and withdraws it with a pair of toothed forceps. The wound should be closed with sutures in layers.

If the loose body cannot be located exactly, or if it slip away in the effort to extract it, a longer incision will be necessary, in the former case preferably in the region of the joint where the attacks of pain are generally felt. Just how far exploration is justifiable must be left to the individual operator, but the wisdom of postponing the search, and trying again is always to be weighed.

After the operation, rest in bed for ten days or two weeks is advisable.

Torn Cartilages.—"Displaced cartilage," "slipped cartilage," "subluxated cartilage," and "internal derangement" are practically synonymous terms, and are employed almost exclusively in reference to the semilunar fibrocartilages of the knee. The difference in nomenclature represents the former confusion as to the exact nature of the lesion. The injury is usually a partial tear of the cartilage, sometimes a complete tear, but rarely if ever a dislocation of the whole cartilage. The inner semilunar cartilage of the knee suffers by far the more frequently. Bennett (1900) reported 155 instances of injury to the inner to forty-

Fig. 3572.—Skiagram of the Knee from which Loose Body shown in Fig 3571 was Removed. Note the area of rarefaction in the inner condyle of the femur. (Reduced ⅓.)

five instances of injury to the outer. Of this number 182 were in men and eighteen were in women, and the ages of the patients ranged from thirteen to sixty-

two years. The reason for the more frequent involvement of the inner cartilage lies in its shape and in its attachment. The tear is usually near the anterior extremity. The outer semilunar is more securely placed than the inner, and its ends are in a way embraced by those of the latter.

The semilunar cartilage is most likely to be torn by a lateral strain upon the knee while the leg is in semi-flexion, and as it is the inner cartilage which suffers more frequently, the lesion usually follows abduction of the leg on the thigh with the knee in semi-flexion, or more frequently abduction of the thigh on the fixed leg. Football players, baseball players, and tennis players are prone to the injury. The occurrence of the lesion is practically impossible in the fully extended leg. In the rare cases of complete tearing off of a portion of the semilunar cartilage the lesion becomes essentially one of loose body in the joint (*q.v.*). Usually, however, the tear is partial, and the torn anterior portion of the cartilage remains attached at one end. It is unstable, slips from its place, and becomes pinched between the bone ends. Its shape may become changed by repeated traumata, and by interference with function.

The symptomatology of a torn semilunar cartilage is much the same as that of a loose body, except that the pain is almost always felt just above the anterior aspect of the top of the tibial tuberosity, usually about four centimeters internally to the patellar tendon. The patient can often indicate the spot with a fair degree of accuracy, and the surgeon's finger can detect the point of sensitiveness exactly. The attacks of pain may be at long intervals at first, but they tend to become more frequent as time goes on, and the joint tends to become more unstable.

Treatment.—This is conservative or operative. For immediate reduction of the displacement during an attack, gentle traction on the semi-flexed leg in the line of deformity may be practised, combined with internal and external rotation. The patient should lie prone during the performance. Sometimes he may be able to shake the cartilage into place himself. Swimming motions have been recommended as particularly useful. I never resort to extreme measures. If I cannot reduce the fragment, I generally leave the patient to his own devices for a day or two, and he will succeed sometimes where I have failed. I let him stand up and shake his leg, lie down and shake it, practise swimming on the floor, etc. Whether the cartilage is back in place or not can usually be told by the possibility of full, painless extension of the knee.

As soon as the displacement is reduced, diagonal criss-cross straps of adhesive plaster about twenty-five centimeters in length should be applied over the front of the knee to exert gentle pressure, and to keep the joint in extension, where it is practically immune to a recurrence of the injury. If the slipping recur later, as it almost invariably does, the treatment may be repeated. A long brace, preventing side strain, and permitting a certain amount of flexion may avail to prevent recurrence. Sometimes the injury will cease to recur under this treatment, but as a rule if the cartilage slip two or three times, an operation will be necessary sooner or later.

The method of operation, following the idea of Jones of Liverpool, is briefly as follows: The patient lies on the table with his leg hanging in flexion over the edge. The operator then makes an incision about one inch internal to the patella, slightly curved, about three inches in length, to a point about one-half inch below the top of the tibial tuberosity. Hemorrhage should be checked before the capsule is opened. The incision into the capsule need not be as long as that through the skin. On opening the capsule the tear of the cartilage usually can be seen. Retractors may be employed if necessary. The fragment should be removed with scissors and toothed forceps, but the finger, always gloved, should never be inserted into the joint. Deep and superficial sutures close the wound. Jones operates with a tourniquet, most other surgeons do not. The operation is always done under general anesthesia, and absolute asepsis must be observed.

LEONARD W. ELY.

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Jones, Henry Bence.—Born at Thorington Hall, Oxford, England, on Dec. 31, 1813. In 1836 he was a pupil at St. George's Hospital, London, and at the same time a private student in Prof. Graham's laboratory at University College. He had already studied animal chemistry under Liebig, in Giessen, Germany. In 1842 he began the practice of medicine in London, and busied himself in making analyses of the urinary calculi in the museum of St. George's Hospital. In 1868, although his health had already began to give way, he was able to deliver the course of Croonian lectures on "Matter and Force" in the College of Physicians. In 1873 the University of Oxford gave him the honorary degree of Doctor of Laws. Several eponyms (Bence Jones' albumin, cylinders, reaction) bear witness to his powers of observation and the value of his researches in clinical medicine. He died April 20, 1893.

Bence Jones' principal published writings are the following: On Gravel, Calculus, and Gout; chiefly an application of Prof. Liebig's physiology to the prevention and cure of these diseases," London, 1842; "Chemistry of Urine," 1857; "On Animal Chemistry in its application to Stomach and Renal Diseases," 1856; and "Lectures on Matter and Tone," 1868.

A. H. B.

Jones, John.—Born in Jamaica, N. Y., in 1729. He studied medicine at the medical schools and

FIG. 3573.—John Jones.

hospitals of London, Paris, Leyden, and Edinburgh. In England he was a warm friend of John Hunter and Percival Pott. On his return to this country,

after a long sojourn in Europe, he settled in New York City. In 1755 he served with Sir William Johnson in the French War. He was Professor of Surgery in King's College, New York City, from 1767 to 1776; he was also one of the two founders of the New York Hospital (1771), Dr. Samuel Bard being the other. In 1778, after Philadelphia had been evacuated by the British, he settled in that city and spent the remainder of his life there. He died in Philadelphia on June 23, 1791.

According to Stone, Jones was regarded as one of the ablest surgeons of his time in America, and especially skilful as an operator in cases of lithotomy. He attended Benjamin Franklin for vesical calculi, and Franklin remembered him in his will as among his personal friends. In 1790 he went to New York to consult in the case of Washington, who suffered at that time from some acute disease of the lungs. "We are indebted," says Stone, "to Dr. Jones for the first American book on surgery, entitled: 'Plain Remarks upon Wounds and Fractures' (New York, 1775). This work was dedicated to Dr. Thomas Cadwalader, and in this dedication he says: 'If I cannot cure the fatal diseases of my unfortunate country, I can at least pour a little balm into her bleeding wounds.'"

A. H. B.

Jones, Joseph.—Born in Liberty County, Georgia, September 6, 1833. He studied medicine at the University of Pennsylvainia, and received the degree of M. D. from that institution in 1855. Between 1856 and 1868 he held successively the following chairs: Professor of Chemistry in the Medical College of Savannah, Ga.; Professor of Chemistry and Geology in the State University, at Athens, Ga.; Professor of Chemistry in the Medical College of Georgia, at Augusta; and Professor of Institutes of Medicine in the University of Nashville, Tenn. In 1868 he removed to New Orleans, Louisiana, and began his duties as Professor of Chemistry in the University of Louisiana (afterward Tulane University) and as Visiting Physician to the Charity Hospital of that city. Later, he greatly improved the New Orleans quarantine service and rendered other valuable services to the State as President of the Louisiana State Board of Health. His death occurred on February 17, 1896.

Dr. Jones was a frequent contributor to medical literature. Among his more important writings the following may be mentioned: "Surgical Memoirs of War of the Rebellion" (New York, 1871); "Hospital Construction and Organization" (Baltimore, 1875); Explorations of the Aboriginal Remains of Tennessee" (Washington, 1876); and "Medical and Surgical Memoirs" (1876–1890). A. H. B.

Journalism, Medical.—Newspapers, periodicals, scientific societies, intelligence offices, and city directories originated, all of them, in the seventeenth century. The pedigree of the scientific periodical is out of the scientific society by the newspaper, and the latter derived from the fugitive "news-letters" and broadsides which were published at odd intervals during the sixteenth century. As it was customary for the poor and illiterate to pay professional scribes some small pittance for writing letters for them, so these news-letters were originally written in long hand, by professional scriveners in the employ of patrons of wealth and station, as a means of obtaining and preserving records of current events. The gradual enlargement of the scriveners' business led to the formation of "intelligence offices," with regular staffs of clerks, like that described in Ben Jonson's comedy "The Staple of News" (1625). Long before this, however, came the Roman *Acta Diurna*, brief bulletins of battles, elections, games, and other events. These were current until the fall of Rome (476 A.D.). The *Peking Gazette* which originated in the seventh century A.D., is still a current Chinese newspaper. About the middle of the sixteenth century, the Venetian government began to issue official leaflets, which were variously known as *gazzette, coranti,* or *foglietti* (1531). The first intelligence office is said to have been founded by a French physician, Théophraste Renaudot (1584–1653), who was also the originator of pawn shops and city directories. The earliest of the seventeenth century newspapers in order of time were the weekly *Frankfurter Journal*, founded by Egenolph Emmel in 1615, the *Nieuwe Tijdinghen* of Antwerp, said to have been founded by Abraham Verhoeven in 1605 (no copy extant anterior to 1616), the *London Weekely Newes* (May 23, 1622), the *Gazette de France*, issued at Paris by Théophraste Renaudot on May 30, 1631, and the solitary number of the *Publick Occurrences* of Boston, edited by Benjamin Harris (September 25, 1690). Just as a library proper is to be distinguished from a collection of archives, so these publications are to be sharply differentiated from such official or political bulletins as the Roman *Acta Diurna*, the Scotch *Diurnal of Occurrents* (1513–75), Janson's *Mercurius Gallo-belgicus* (1587–94), the *Diurnals of Parliament* (1641–42), or Marchamont Nedham's *Mercurius Britannicus* (1643–46).

After the foundation of such learned societies as the Roman Accademia dei Lincei (1603), the Royal Society (1660), the French Académie des sciences (1666), or the Imperial Leopoldine Academy or Academia naturæ curiosorum (1677), came, in due course their scientific transactions, in particular the Gesta Lynceorum (1605), the *Transactions* of the Royal Society (1665), the *Miscellanea* or *Ephemeride*, of the Leopoldine Academy (1670–1706), the *Mémoires* of the French Académie des sciences (1699), the *Acta medica Hafniensia* (Copenhagen), edited by the anatomist Thomas Bartholinus (1671–9), and the *Acta eruditorum* of Leipzig (1682–1745). The *Journal des sçavans* of Paris (January 5, 1665) was the earliest of the scientific periodicals proper (as distinguished from belletristic journals or scientific transactions) giving reviews of books and reports on scientific progress. To France is also due the first periodical to be devoted to medicine, which was the *Nouvelles découvertes sur toutes les parties de la médecine*, edited by Nicolas de Blegny (Paris, 1679–81). This was also the first medical periodical printed in the vernacular, and its popularity is evidenced by the fact that it was translated into German as *Monatliche neu eröffnete Anmerckungen* (Hamburg, 1680) and into Latin as the *Zodiacus medico-gallicus* (Geneva, 1680–85), in which form it was continued by Théophile Bonet. In 1681 a *Journal de médecine* was founded by the abbé J. P. de la Roque, which, dying out in 1685, was continued by Claude Brunet (1686), who also edited a monthly *Progrès de la médecine* (1695–1709).

In the eighteenth century, the example set by de Blegny's *Nouvelles découvertes* (1679) was followed in a large number of scientific and medical repositories of similar character, containing bulletins of scientific progress, abstracts of case-reports, reviews of books, and the like. The earliest of these in time was a series of about four hundred miniature volumes entitled "*Mémoires pour l'histoire des sciences et des beaux arts* (1701–75), originally printed at Trevoux, France. Germany had by far the largest number of these collections, in some sort the equivalent of our year books, the earliest being the thirty-eight volumes of *Geschichten*, edited by Johann Kanold of Breslau (1717–30), which was followed by the *Commercium litterarium ad rei medicæ et scientiæ naturalis incrementum* (15 vols., Nuremberg, 1731–45), the *Selecta medica Francofurtensia* (1736), the *Medicorum Silesiacorum*

satyræ (1736), Haller's *Gottingsche Zeitungen von Gelehrten-Sachen* (1739–74), C. G. Ludwig's *Commentarii* (Leipzig, 1752–1808), F. A. Weiz's *Vollständige Auszüge* (Leipzig & Budissin, 1769–83), N. G. Leske's translation-abstracts from the Philosophical Transactions (1774–78), Schlegel and Arnemann's *Medizinische Literatur* (Leipzig, 1780–94), A. F. Hecker's *Auswahl* (1787–88), Hufeland's *Neueste Annalen der Französischen Arzneykunde* (Leipzig, 1791–1800), C. G. Hopf's *Commentarien* (Tübingen, 1792–1800), and Hecker's *Journal der Erfindungen* (Gotha, 1792–1809). In France, the same tendency is observable in F. Planque's *Bibliothèque choisie de médecine* (Paris, 1748–70), the *Nouvelles instructives* (Paris, 1785–87; continued as *Nouvelles, ou annales*, 1789–91), citoyen Brewer's *Bibliothèque germanique médico-chirurgicale* (Paris, 1789–99); in Switzerland by the *Acta Helvetica* (Basel, 1751–77), P. R. Vicat's *Bibliothèque médico-physique du nord* (Lausanne, 1783–84), and P. Usteri's *Repertorium* (Zürich, 1789–95); in Italy, by the *Raccolta of* V. Azzolino (Venice, 1759), the *Florentine Raccolta* (1773) and L. Brugnatelli's *Biblioteca fisica d'Europa* (Pavia, 1788–91), which was continued as the monthly *Giornale fisico-medico* (Pavia, 1792–94); and even by similar publications in Norway and Denmark.

Meanwhile, throughout the century, a large number of scientific and medical societies were formed, in particular, the *Royal Academy of Sciences* at Berlin (*Königliche Akademie der Wissenschaften*, 1700), the *Académie royale de chirurgie* of Paris (1731), the *Royal Medical Society of Edinburgh* (1737), the *Royal Swedish Academy* (1739), the *Königliche Gesellschaft der Wissenschaften* at Göttingen (founded by Haller, 1751), the *Königliche bayerische Akademie der Wissenschaften* at Munich (1759), the *Medical Society of London* (1773), the *Société royale de médecine* of Paris (1776), the *Abernethian Society* (London, 1795), the *Société de médecine de Paris* (1796), and the *Royal College of Surgeons* at London (1800). In America, medical societies had been founded at Boston (1735), Philadelphia (1765), and New York City (*circa* 1769), and State medical societies in New Jersey (1766), Massachusetts (1781), South Carolina (1789), Delaware (1789), New Hampshire (1791), Connecticut (1792), and Maryland (1798). There were also such learned bodies as the *American Philosophical Society* (1743), and the *American Academy of Arts and Sciences* (Boston, 1780), the *College of Physicians of Philadelphia* (1787), and the *Medical and Chirurgical Faculty of Maryland* (1789). In the modern scale of values, the transactions of some of these societies constitute the most important part of the periodical literature of medicine in the eighteenth century. Thus, the *Histoire* of the Académie royale des sciences contains Lavoisier's memoirs on the discovery of oxygen and the interchange of gases in the lungs, as also the work of Réaumur on digestion in birds; the Philosophical Transactions (Royal Society) contain Priestley's discovery of oxygen, Cavendish's discovery of hydrogen, Freke's description of myositis ossificans, Machin's account of ichthyosis histrix, Watson's account of scleroderma, and Wollaston on gouty and urinary concretions. William Hunter's paper on arteriovenous aneurysm (1757) is printed in the Medical Observations and Inquiries by a Society of Physicians in London, Heberden's account of angina pectoris in the Medical Transactions of the Royal College of Physicians; in the Transactions of a Society for Improvement of Medical and Chirurgical Knowledge (London, 1793–1812) we find John Hunter's method for operating for aneurysm (1786), Lettsom on the drug-habit (1786), is in the Memoirs of the Medical Society of London, and Dalton's original account of color blindness (October 31, 1794) is found in the Memoirs of the Literary and Philosophical Society of Manchester. The first volume of the *Commentarii Societatis regiæ Scientiarum Gottingensis* (1752–76) contains Haller's original experiment on the specific irritability of tissues (November 10, 1751, pp. 263–266), and in the Transactions of the Imperial Academy of Sciences of St. Petersburg (1726–1802) is buried Wolff's great monograph on the development of the intestines (1768–69). In 1788, the Medical Society of New Haven County, Connecticut (founded 1784) issued a slim volume of "*Cases and Observations*," containing Hezekiah Beardsley's original account of congenital pyloric stenosis. Transactions were published by the Massachusetts Medical Society in 1790, and by the College of Physicians of Philadelphia in 1793.

Of medical periodicals proper, the earliest was *Der patriotische Medicus* (Hamburg, 1724–26), a small weekly, not unlike the "Spectator" or the "Tatler" in size, shape, and character. The most important were the *Recueil périodique d'obsérvations de médecine* (Paris, 1754–57) which afterward became the *Journal de médecine, chirurgie et pharmacie* (Paris, 1758–93); the *London Medical Journal* (1781–90) continued as *Medical Facts and Observations* (1791–1800); the *Annales de chimie* (Paris, 1790–1815), the *Medicinisch-Chirurgische Zeitung* (Salzburg, 1790–1842), Desault's *Journal de chirurgie* (Paris, 1791–92); Trommsdorf's *Journal der Pharmacie* (Leipzig, 1793–1817); Reil's *Archiv für die Physiologie* (Halle, 1795–1815), and Hufeland's *Journal der praktischen Arzneykunde* (Jena, Berlin, 1795–1844). As will appear from this list, most of the medical periodicals publishing original cases and scientific observations began to appear toward the end of the century and the great preponderance of these were German. The *Journal de médecine militaire* (Paris, 1782–88), was the original of "*A Journal of the Practice of Medicine, and Surgery and Pharmacy in the Military Hospitals of France*," annotated from the French by Joseph Brown, of which No. 1 of volume 1, was published in New York about 1790, making 120 pages of selected translations. The first original medical journal to be published in America was a quarterly, *The Medical Repository* (New York, 1797–1824), edited by Samuel L. Mitchell, Edward Miller, and Elihu H. Smith. With the exception of its predecessor, this was the only American medical journal to be printed in the eighteenth century, and its popularity is evidenced by the fact that the first and second volumes had a second edition in 1800 and a third in 1804–05.

As the medical journals of the eighteenth century have never before been brought together, a fairly complete check-list is subjoined in chronological order. It does not include purely scientific transactions nor such scrap-books of miscellaneous data as have been described above.

1717–31	Acta medicorum Berolinensium.
1719–23	Annalium physicomedicorum. 4 v. Leipzig & Budissin.
1724–6	Patriotische (Der) Medicus. Nos. 1–59, Hamburg.
1733–44	Medical Essays and Observations by a Society in Edinburgh. 5 v.
1743–87	Mémoires de l'Académie royale de chirurgie. 15 v. Paris.
1754–93	Recueil périodique (etc.), continued as Journal de médecine (etc.). 95 v. Paris
1757–84	Medical Observations & Inquiries by a Society of Physicians in London. 6 v.
1759–64	Arzt (Der). ed. A. Unzer. 12 v. Hamburg.
1762–76	Giornale di medicina (Gazzetta medica d'oltremonti) 13 v. Venice.
1763–64	Medical (The) Museum. 3 v. London.
1765–7	Artzneien. ed. E. G. Baldinger. 2 v. Langensalza.
1767–70	Medicinisches Journal. ed. G. Schuster. 2 v. Chemnitz.
1767–70	Geneeskundig Tijdschrift. ed. A. Lentfrinck. 4 v. Rotterdam.
1768–85	Medical Transactions . . . Royal College of Physicians of London. 6 v.
1771–3	Arzt (Der) der Frauenzimmer. 3 v. Leipzig.
1771–97	Chirurgische Bibliothek. ed. A. G. Richter. 15 v. Gottingen & Gotha.
1774–5	Societatis medicæ Havniensis Collectanea. 2 v. Copenhagen.

1774–95 Medical and Philosophical Commentaries, by a Society of Physicians in Edinburgh (Annals of Medicine, 1796–1804). 20 v. London.
1775 Acta regiæ Hafniensia. 1 v. Copenhagen & Leipzig.
1775–7 Philosophische (Der) Arzt. Pts. 1–4. Frankfurt etc.
1775–8 Magazin für Aerzte. ed. E. G. Baldinger. Leipzig. (Continued as Neues Magazin, 1779–99). 22 v.
1775–87 Medicinisch-Chirurgische Bibliothek. ed. J. C. Tode. 10 v. Copenhagen.
1776 Abhandlungen und Beobachtungen aus der Arzneygelahrtheit von einer Gesellschaft von Aerzten in Hamburg. ed. P. D. Giseke. 1 v. Hamburg.
1776–89 Histoire de la Société royale de Médecine. 10 v. Paris, 1779–98.
1776–92 Handelingen van het geneeskundig genootschap onder de zinspreuk: Servandis civibus. 10 v. Amsterdam.
1777–9 Acta Societatis medicæ Havniensis. 2 v. Copenhagen.
1778–81 Sundheds-tidende. ed. J. C. Tode. 3 v. (Continued as Nye Sundheds-Tidende, 1782–3, 2 v.) Copenhagen.
1780–89 Medizinisches Wochenblatt für Aerzte, Wundärzte und Apotheker. ed. J. J. Reuckard. 10 v. Frankfurt a. M.
1781 Medizinische Annalen (1779–80). ed. J. G. Fritze. 1 v. Leipzig.
1781–8 Wecko-Skrift for läkare och naturforskare. 9 v. Stockholm.
1781–90 London Medical Journal. ed. Dr. Simmons. 11 v. (Continued as Medical Facts and Observations, 1791–1800, 8 v.)
1782–4 Magazin für die gerichtliche Arzneikunde. ed. K. F. Uden. 2 v. (Continued as Neues Magazin, 1785–8, 2 v.) Stendal.
1782–6 Gazette de Santé (Gemeinnütziges medicinisches Magazin). ed. J. H. Rahn. 5 v. Zürich.
1782–8 Journal de médecine militaire. ed. M. De Horne. 7 v. Paris.
1783 Acta medicorum Suecicorum. 1 v. Holm.
1783–95 Giornale per servire alla storia ragionata della medicina di questo secolo. 10 v. Venice.
1783–7 Archiv der medizinischen Polizei. ed. J. C. F. Scherf. 6 v. (Continued as Beitrage, 1788–99, 8 v.) Leipzig.
1783–8 Medicinische Bibliothek. ed. J. F. Blumenbach. 3 v. Göttingen.
1783–93 Aufsätze und Beobachtungen aus der gerichtlichen Arzneywissenschaft. ed. J. T. Pyl. Samml. 1–8. Berlin.
1783–93 Verhandelingen van de Natuur- en Geneeskundige Correspondentie Societeit, in de Vereenigde Nederlanden (1779–90). 4 v. The Hague.
1783–1829 Acta regiæ Societatis medicæ Havniensis. 7 v. Copenhagen.
1784–90 Medical Communications (of the Society for Promoting Medical Knowledge). 2 v. London.
1784–96 Medizinisches Journal. ed. C. G. Baldinger. 9 v. Göttingen. (Continued as Neues medicinisches und physisches Journal, 1797–1802, 3 v. Marburg.)
1785–6 Geneeskundige Bibliotheek. Pt. 1–2. Utrecht.
1785–6 Medicinischer Briefwechsel von einer Gesellschaft von Aerzten herausgegeben. Halle.
1785–6 Sundhedsblade. ed. J. C. Tode. Copenhagen.
1785–7 Archiv der praktischen Arzneykunst. ed. P. F. T. Meckel. 3 v. Leipzig. (Continued as Neues Archiv, 1789–90.)
1785–1820 Medical Transactions, published by the Royal College of Physicians of London. 6 v.
1786–7 Sundhed og Underholdning. ed. J. C. Tode. Copenhagen.
1787 Journal d'observations de médecine, chirurgie et pharmacie. ed. Sieur Denis. 1 v. Calais.
1787–8 Archiv für Magnetismus und Somnambulismus. ed. F. L. Bockmann. Strassburg.
1787–97 Archiv für die Geburtshülfe. ed. J. C. Stark. 6 v. (Continued as Neues Archiv, 1798–1804, 3 v.) Jena.
1787–1805 Memoirs of the Medical Society of London. 6 v.
1788 Cases and Observations by the Medical Society of New Haven County. 1 v. New Haven.
1788–91 Magazin für die Naturgeschichte des Menschen. ed. C. Grosse. 3 v. Zittau and Leipzig.
1789–90 Taschenbuch für deutsche Wundärzte. ed. F. A. Weiz. (Continued as Medicinisch-chirurgische Aufsätze, 1791–3, 3 v.) Altenburg.
1790 Archiv für die Geschichte der Arzneikunde. ed. P. L. Wittwer. v. 1, No. 1. Nuremberg.
1790 Journal (A) of the Practice of Medicine, Surgery, and Pharmacy in the military hospitals of France. No. 1 v. 1. New York.
1790 Medical Papers communicated to the Massachusetts Medical Society. No. 1. Boston.
1790–91 Annalen der Staatsarzneykunde. ed. J. D. Metzger. 1 v. Zullichau. (Continuation of Elsner & Metzger's Gerichtlich-medizinische Bibliothek, 1784–9.)
1790–92 Archiv für die allgemeine Heilkunde. ed. A. F. Hecker. 2 v. (Continued as Neues Archiv, 1793–9.) Berlin.
1790–93 Medizinisches Wochenblatt. ed. Müller & Hoffman. 7 v. Frankfurt a. M.
1790–1842 Medicinisch-chirurgische Zeitung. ed. J. J. Hartenkeil & J. X. Mezler (1790–93) and later (up to 1842) by L. von Erhartstein. 212 v. with 13 suppl. vols. Salzburg.
1791–2 Journal de chirurgie. ed. P. J. Desault. 4 v. Paris.
1791–2 Tirolische (Der) Arzt. ed. K. M. Scheiter & I. Niedermaier. 2 v. Innsbruck.
1791–3 Medicinisch-chirurgische Aufsätze. ed. F. A. Waitz. 3 v. Altenburg.
1791–3 Medical (The) Spectator (weekly). 2 v. London.
1791–1805 Verhandelingen der Genootschap ter Bevordering der Heelkunde te Amsterdam. 4 v.
1791–1807 Prijsverhandeligen bekroond door het Genootschap ter Bevordering der Heelkunde te Amsterdam. 3 v.
1792 Bibliothek für Kinderärzte. 1 v. Vienna.
1792–3 New (The) London Medical Journal. 2 v.
1792–7 Museum der Heilkunde. Hrsg. von der helvetischen Gesellschaft correspondirender Aerzte und Wundärzte. 4 v. Zurich.
1793 Transactions of the College of Physicians of Philadelphia. v. 1. pt. 1.
1793–4 Annalen der Geburtshülfe, Frauenzimmer- und Kinderkrankheiten. 1790–91. ed. J. J. Römer. 2 v.
1793–4 Medicinische Cronik. ed. J. Eyerel. 3 v. Vienna.
1793–4 Sundheds-Journal. ed. J. C. Tode. Copenhagen.
1793–1804 Medicinisches Journal. ed. J. C. Tode. 5 v. Copenhagen & Leipzig.
1793–1809 Journal der Erfindungen (etc.). ed. A. F. Hecker. 11 v. Gotha. (Continued as Annalen der gesammten Medicin, 1810–11. 3 v. Leipzig).
1793–1812 Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge. 3 v. London.
1793–1817 Journal der Pharmacie. ed. J. B. Trommsdorf. 26 v. Leipzig.
1794 Landarzt (Der). ed. J. G. Essig. 1 v. Augsburg.et
1794 Magazin für Geburtshelfer. ed. C. L. Schweickhard. 1 v. Frankfurt a. M. & Leipzig.
1794–5 Denkwürdigkeiten für die Heilkunde und Geburtshülfe. ed. F. B. Osiander. 2 v. Gottingen. (Continued as Neue Denkwürdigkeiten, 1797).
1794–6 Beitrage zur Geschichte der Medicin. ed. K. Sprengel. 1 v. Halle.
1795–1815 Archiv für die Physiologie. ed. J. C. Reil. 12 v. Halle. (Continued as Deutsches Archiv. 1815–23. 8 v.)
1795–1839 Berlinisches Jahrbuch für die Pharmacie. 41 v. Berlin.
1795–1844 Journal der praktischen Arzneykunde. ed. C. W. Hufeland. 98 v. Jena, Berlin.
1796 Magazin für die pathologische Anatomie und Physiologie. ed. A. F. Hecker. 1 v. Altona.
1796–99 Archiv der Aerzte und Seelsorger, wider die Pockennoth. ed. C. W. Juncker. 7 pts. Leipzig.
1797–1802 Recueil périodique de la Société de Santé de Paris. 14 v.
1797–1803 Journal für Chirurgie, Geburtshilfe und gerichtliche Arzneikunde. ed. J. C. Loder. 4 v. Jena.
1797–1803 Magazin für die Wundarzneiwissenschaft. ed. J. Arneman. 3 v. Göttingen.
1797–1824 Medical Repository. ed. S. L. Mitchell *et al.* 23 v. New York.
1798 Medical Records and Researches, selected from the papers of a private medical association. 2 pts. London.
1798–9 Philosophische (Der) Arzt. ed. M. A. Weikhard. 3 v. Leipzig.
1798–9 Medizinische Nationalzeitung für Deutschland. 2 v. (Continued as Allgemeine medizinische Annalen, 1800–30, 33 v.) Altenburg.
1798–1808 Beiträge zur theoretischen und practischen Geburtshülfe. ed. J. H. Wigand. 3 pts. Hamburg.
1799–1800 Schwedische Annalen der Medicin und Naturgeschichte. ed. K. A. Rudolph. 1 v. Berlin & Stralsund.
1798–1801 Recueil des actes de la Société de santé de Lyon. 2 v.
1799–1801 Annales instituti medico-clinici Wirceburgensis. ed. J. N. Thomann. 2 v. Wurzburg.
1799–1805 Nordisches Archiv für Natur- und Arzneywissenschaft. ed. Pfaff & Scheel. 4 v. Copenhagen.
1799–1809 Magazin zur Vervollkommnung der theoretischen und praktischen Heilkunde. ed. A. Roschlaub. 10 v. Frankfurt a. M.

1799–1814 Medical (The) and Physical Journal. ed T. Bradley & A. F. M. Willich. 32 v. London.
1799–1841 Bibliothek der praktischen Heilkunde. ed. C. W. Hufeland (*et al*.) 86 v. Jena, Berlin.

The most casual survey of the above list will convince anyone acquainted with the medical literature of the eighteenth century that its best things are contained in the medical and scientific transactions. Much of the unwritten cultural history of medicine in this century is undoubtedly buried, as Sudhoff intimates, in the files of its forgotten medical periodicals.

The modern period has been the age not only of medical journals proper, but also of the rise of medical *journalism* as a separate and distinct profession. The great increase in number of medical periodicals was due, of course, to the growth of the democratic spirit all over the civilized world and to the evolution of the different medical specialties as part of the organized advancement of science which went along with the social democratic movement. The rise of industrial democracy and socialism following upon the French Revolution brought about an entire realignment of the social order and one of its special creations or creatures was the journalist. About 1850, in consequence of the vast improvements in mechanic arts and machinery, the old order of an aristocracy of birth, rank, and breeding, a middle class of moderate competency and culture, and a lower class of artisans and rustics was gradually displaced by the modern capitalistic régime and the industrial proletariat which waited upon its interests. The wealthy manufacturer of the Cobden-Manchester school, who sought to erect himself into a moneyed *Patrizier* on his own account, made war on the old *noblesse*, and was, in his turn, devoured by the wealthier capitalist. The inevitable shifting of leadership resulting from this political and social strife created the need for a direction, or in the current cant phrase, a "moulding" of public opinion. In this way, the pressman and the journalist acquired new and unheard of powers and the medical journalist, as distinguished from the editor of the scientific medical periodical pure and simple, made his appearance.

The founder of medical journalism as an agency in the organization and direction of public opinion and of legislation, was Thomas Wakley (1795–1862), a Devonshire man whose whole life was taken up with public propagandism for the advancement of English medicine and the abolition of social injustice. Having studied medicine, Wakley's practice was ruined by murderous assault and incendiarism at the hands of ruffians connected with the Thistlewood conspiracy (1820–21); and, in 1823, he founded the "*Lancet*," a medical journal devoted, in the first instance, to the circulation of recent medical knowledge and to the exposure and correction of abuses perpetrated by the metropolitan hospitals and corporations. Until very recently, the London hospitals have been in the nature of close corporations of ancient date, supported by large endowments or by annual subscriptions which, in the vigorous language of J. S. Billings, "can be obtained in England more easily than in any country under the sun and for almost any object which can be proposed. The subscribers are usually entitled to vote, whence it happens that, in case of any dispute, a wealthy person interested can make his footman, bootblacks, etc., subscribers and governors, and thus get votes enough to carry his point." In the early part of the nineteenth century, one heritage of the privileged medical class was the old eighteenth century idea that a medical practice or professorship is an exclusive property of the individual. Practice was inherited from father to son or from patron and preceptor to pupil and friend. In Edinburgh, the Monro dynasty kept the chair of anatomy in the family for 126 years (1720–1846). In Wakley's day, the medical staff of the London hospitals were fain to regard their clinical lectures as private property of the hospital exclusively, and there were many intrigues and imbroglios connected with the matter of appointments and promotions in hospitals and corporate medical institutions. In the first number of the *Lancet* (October 5, 1823), Wakley boldly began the publication of shorthand reports of hospital lectures; in 1825–28, he opened up the subject of malpractice in hospitals, and his reviews and animadversions upon current books and events were extremely caustic. The surgeon James Wardrop acquired a special odium in this connection through his diatribes against the London profession in the *Lancet* of 1826–27 and 1834. The attempt of John Abernethy to obtain an injunction in chancery restraining the publication of his surgical lectures in 1824 was defeated by legal opinion (Lord Eldon) to the effect that hospital lectures, being delivered in a public capacity, are public property. This was a great victory for the medical journalist and for the advancement of medicine. Wakley's subsequent reforms in connection with hospital abuses and vested interests form a chapter in itself. In 1851, he began his famous attacks on the adulteration and sophistication of foods and drugs. Entering Parliament in 1835, he was, in 1839, elected coroner for West Middlesex, and in these capacities he accomplished more for social medicine than any other man of his time. In 1847, he became his own publisher, removing the *Lancet* to its present offices at 423 Strand, and the journal is still one of the strongest and liveliest organs of medical opinion in the modern world.

On July 19, 1832, the British Medical Association was organized by Sir Charles Hastings. The pedigree of its literary organ, the *British Medical Journal* (founded 1857) is through its *Transactions* (1832–53), the *Provincial Medical and Surgical Journal* (1840–53) and its successor, the *Association Medical Journal* (1853–57). The *British Medical Journal* is the organ of the united medical profession of Great Britain, and has played a great part in the development of medical reforms, in the steering of parliamentary bills relating to public health legislation and poor laws, and in the exposure of quackery, malpractice, and patent medicine frauds.

The *Journal of the American Medical Association*, founded in 1883 by Nathan Smith Davis and now edited by George H. Simmons, is the literary organ of the American Medical Association (founded 1847), and in its aims and methods has followed the lead of the two great English organs of medical opinion, particularly in its attacks on quackery, proprietary medicines, diploma mills, unlicensed practitioners, inferior medical schools, and other factors which tend to degrade the status of American medicine. It has done much for the illumination and direction of public opinion, particularly in the much needed centralization of medical societies and their journals and in the securing of four-year courses and full-time professorships for the better class of medical schools.

The earliest medical journals in the United States after the *Medical Repository* (1797), were the *Philadelphia Medical Museum* (1804–11), the *Philadelphia Medical and Physical Journal* (1804–09), the *Medical and Agricultural Register* (Boston, 1806–07), the *Baltimore Medical and Physical Recorder* (1808–09), the *American Medical and Philosophical Register* (New York, 1810–14), the *New England Journal of Medicine and Surgery* (Boston, 1812–28), the *American Medical Recorder* (Philadelphia, 1818–29), and the *Philadelphia Journal of the Medical and Physical Sciences* (1820). The first medical journal to be printed west of the Alleghenies was the *Western Quarterly Reporter of Medical, Surgical and Natural Science* (Cincinnati, 1822), edited by the ill-starred Maryland anatomist, John D. Godman. The first Canadian medical journal was the *Journal de médecine de Quebec* (1826–27).

Of medical periodicals which assimilate to the *Lancet* and *British Medical Journal* in type, we may mention, in the earlier period, the *Archiv für medizinische*

Erfahrung (Leipzig, 1801–02, Berlin, 1803–36), founded and edited by Ernst Horn, originally an organ of the Nature Philosophy School but later eclectic and, all in all, the most important German periodical of its time; the *Lancette française* (1828), now the *Gazette des hôpitaux*, the *Gazette médicale de Paris* (1830), and the *American Journal of the Medical Sciences* (1827). The latter, originally the *Philadelphia Journal of the Medical and Physical Sciences* (1820), founded by Nathaniel Chapman, became, under the editorship of Isaac Hays, I. Minis Hays, and others, the best of the American medical monthlies for a long period and was known as "Hays' Journal." At present it is more in the nature of a repository of original contributions on internal medicine. In Germany, periodicals of the type and authoritative influence of the *Lancet* did not begin to appear generally until after the foundation of the Empire in 1871. At the present time, the *Deutsche medicinische Wochenschrift* (Berlin, 1875), is the best and most important of these. In the same class belong the different *Wochenschriften* of Berlin (1864), Munich (originally *Aerztliches Intelligenz-Blatt*, 1854), Prague (1876), Vienna (1851), St. Petersburg (1876), the *Nederlandsch Tijdschrift voor Geneeskunde* (Amsterdam, 1857), the *Correspondenzblat für schweizer Aerzte* (Basel, 1871), the *Progrès médical* (Paris, 1873), *Vrach* (St. Petersburg, 1880), and such American weeklies as the *Boston Medical and Surgical Journal* (1828), the *Medical News* (Philadelphia, 1843–1905), founded by I. Minis Hays, the *New York Medical Journal* (1865, current), the *Medical Record* (1866, current), edited by George F. Shrady and latterly by Thomas L. Stedman, the *Philadelphia Medical Journal* (1898–1903) and *American Medicine* (1898), both founded by George M. Gould. Of medical monthlies called after the names of cities among the best are the *Edinburgh Medical Journal* (1855), originally the *Edinburgh Medical and Surgical Journal* (1805–55), the *Glasgow Medical Journal* (1828), the *Dublin Journal of Medical Science* (1832), the *Lyon médical* (1869), the *Liverpool Medico-Chirurgical Journal* (1881), the *Bristol Medico-Chirurgical Journal* (1883), *Paris médical* (1910), which are not unlike Hays' Journal in character and excellence, while those associated with the names of Birmingham, Bordeaux, Budapest, Buffalo, Cincinnati, Cleveland, Denver, Detroit, Lille, Marseilles, Nantes, Memphis, Montpelier, Louisville, Richmond, Rome, St. Paul, Venice, and other cities, are of varying degrees of merit. These periodicals, essentially modern in character, contain besides original papers, clinical and surgical cases, reports of progress, abstracts, reviews, translations, facetiæ, and bits of medical gossip. More exclusively devoted to internal or clinical medicine are the *Archives générales de médecine* (Paris, 1823, current), the *Bulletin et mémoires de la Société médicale des hôpitaux de Paris* (1849), the *Deutsches Archiv für klinische Medicin* (Leipzig, 1865), the *Nordiskt medicinskt Arkiv* (Stockholm, 1869), the *Archivio per le scienze mediche* (Turin, 1876), the *Riforma medica* (Naples, 1885), the *Clinica moderna* (Florence, 1895), the *Medicinische Klinik* (Berlin, 1905), *Tommasi* (Naples, 1905), the *Quarterly Journal of Medicine* (London, 1907), *Archives of Diagnosis* (New York, 1908), and *Archives of Internal Medicine* (Chicago, 1908). This brings us to the scientific medical periodicals, devoted to the fundamental disciplines, to the different medical specialties, and to isolated subjects which have become specialized during the twentieth century.

These periodicals began to make their appearance about the middle of the nineteenth century. In the earlier period, there were such journals as Siebold's *Lucina* (Leipzig, 1802–11), Langenbeck's *Bibliothek für die Chirurgie* (Göttingen, 1805–13), Oken's *Isis* (Leipzig, 1818–48), Grafe's and Walther's *Journal der Chirurgie und Augen-Heilkunde* (Berlin, 1820–50), Magendie's *Journal de physiologie expérimentale* (Paris, 1821–31), Tiedemann's *Zeitschrift für Physiologie* (Heidelberg, 1824–35), the *Bulletin de la Société anatomique de Paris* (1826, current), the *Mémoires* (1828) and *Bulletin* (1836) of the *Académie de médecine* of Paris, the *Comptes rendus* of the *Académie des sciences* of Paris (1835, current), Malgaigne's *Journal de chirurgie* (Paris, 1843–46), and Florin Heller's *Archiv für physiologische und pathologische Chemie* (Vienna, 1844–47); but their number was not large, and such repositories as Froriep's *Notizen* (Weimar, 1821–49), the *British and Foreign Medical Review* (London, 1836–77), Canstatt's *Jahresbericht* (Erlangen, 1842–65, continued by Virchow 1874–1902), and Graevell's *Notizen* (1848) the originals of our own bulcy "year-books," were largely used for general medical information. The main currents of scientific medicine in modern Germany can be traced in the files of four important periodicals, viz., Johannes Müller's *Archiv für Anatomie, Physiologie und wissenschaftliche Medicin* (Berlin and Leipzig, 1834–57, continued by Reichert and Du Bois Reymond, 1858 to date), the pedigree of which can be traced down from Reil's *Archiv für die Physiologie* (1795), Henle and Pfeufer's *Zeitschrift für rationelle Medicin* (1841–69), Roser and Wunderlich's *Archiv für physiologische Heilkunde* (1842–59), and Virchow's *Archiv für pathologische Anatomie* (1847, current). In 1848, the *Société de biologie* de Paris was founded and began to publish its admirable *Comptes rendus* in 1850; and, in 1854, the *Royal Society* of London began the publication of its *Proceedings* (abstracts of transactions, 1800–54). From this time on there was a constant succession of imposing publications devoted to the fundamental scientific disciplines, such as Traube's *Beiträge zur experimentellen Pathologie* (1846), Kölliker's *Zeitschrift für wissenschaftliche Zoologie* (1849), Moleschott's *Untersuchungen* (1857), Brown-Séquard's *Journal de la physiologie de l'homme et des animaux* (1858–63), Robin's *Journal de l'anatomie et de la physiologie* (1864), Max Schultze's *Archiv für mikroskopische Anatomie* (Bonn, 1865), Pettenkofer's *Zeitschrift für Biologie* (1865), Ludwig's *Arbeiten* (1866–77), Pflüger's *Archiv für die gesammte Physiologie* (1868), the *Archiv für experimentelle Pathologie und Pharmakologie*, founded by Klebs, Naunyn, and Schmiedeberg (1873), Gegenbaur's *Morphologisches Jahrbuch* (1875), Cohn's *Beiträge für Morphologie der Pflanzen* (1875), Hoppe-Seyler's *Zeitschrift für physiologische Chemie* (1877), Sir Michael Foster's *Journal of Physiology* (London, 1878), and Van Beneden's *Archives de biologie* (1880). At the same time, there was a vast proliferation of periodicals devoted to the different specialties, increasing in volume and variety toward the end of the century. Clinical medicine, dentistry, dermatology, dietetics, electrotherapy, gynecology, hydrotherapy, hygiene, hypnotism, laryngology and rhinology, medical jurisprudence, military medicine, neurology, nursing, obstetrics, orthopedics, otology, pediatrics, pharmacy, psychiatry, radiology, surgery, therapeutics, tropical medicine, urology, and veterinary medicine are all well represented in this respect, and such periodicals are now usually good of their kind in almost any country. The dental and homeopathic journals and those devoted to anti-vivisection, osteopathy, etc., are as a rule poor in quality. Anthropology is well represented, as are also such new subjects as developmental mechanics, biometrics, eugenics, psychoanalysis, and the like.

Of current journals devoted to the scientific disciplines and specialties which have attained a high degree of scientific merit, we may specify Graefe's *Archiv für Ophthalmologie* (1854), Langenbeck's *Archiv der klinischen Chirurgie* (1861), Ziemssen's *Zeitschrift der klinischen Medicin* (1868), Griesinger's *Archiv für Psychiatrie* (1868), Credé's *Archiv für Gynaekologie* (1870), Volkmann's *Sammlung klinischer Vortrage* (1870), the *Deutsche Zeitschrift für Chirurgie* (1872), Charcot's *Nouvelle Iconographie de la Salpêtrière* (1876), the *Zeitschrift für klinische Medizin*

(Frerichs and Leyden, 1879), Charcot's *Archives de neurologie* (1880), the *Revue de médecine* (Landouzy and Lepine, 1881), the *Revue de Chirurgie* (Verneuil and Nicaise, 1881), Pettenkofer's *Archiv für Hygiene* (1883), Koch's and Flugge's *Zeitschrift für Hygiene und Infektionskrankheiten* (1886), Leuckart's and Loeffler's *Centralblatt für Bakteriologie und Parasitenkunde* (1887), the *Annales de l'Institut Pasteur* (1889), Hutchinson's *Archives of Surgery*, Hoffa's *Zeitschrift für orthopädische Chirurgie* (1891), Roux's *Archiv für Entwicklungsmechanik* (1894), Hegar's *Beiträge zur Geburtshülfe und Gynäkologie* (1898), Nuttall's *Journal of Hygiene* (1901), Galton's and Pearson's *Biometrika* (1901), Schaudinn's *Archiv für Protistenkunde* (1903), Caspar's *Zeitschrift für Urologie* (1907), Nuttall's *Parasitology* (1908), and Sudhoff's *Archiv für Geschichte der Medizin* (1908). Each of these periodicals represents a "real value" in scientific medicine and has associated with it the peculiar *cachet* of a distinguished editorial name. Toward the beginning of the twentieth century, a number of American laboratories and institutes devoted to experimental research in medicine began to spring up, and there was, in consequence, a simultaneous outcropping of high-class periodicals, devoted exclusively to original investigations. The best of these are the *Journal of Morphology* (1887), founded by Charles O. Whitman; the *Journal of Experimental Medicine* (1896), founded by William H. Welch; the *Journal of Medical Research* (1896), founded by Harold C. Ernst; the *American Journal of Physiology* (1898), founded by H. P. Bowditch; the *American Journal of Anatomy* (1901); the *Journal of Infectious Diseases* (1904), founded by Ludvig Hektoen; the *Journal of Experimental Zoology* (1904), edited by Ross Granville Harrison; the *Journal of Biological Chemistry* (1905), founded by Christian A. Herter; the *Journal of Experimental Pharmacology and Therapeutics* (1909), founded by John J. Abel, and the *Bio-Chemical Bulletin* (1912). America has also a goodly number of fine periodicals devoted to the specialties, such as the *American Journal of Insanity* (1844), the *American Journal of Obstetrics* (1868), founded by Emil Noeggerath and Abraham Jacobi, the *Archives of Ophthalmology and Otology* (1869), founded by Hermann Knapp, the *Journal of Nervous and Mental Diseases* (1876), the *Journal of Cutaneous Diseases* (1882), the *Annals of Surgery* (1885), the *American Journal of Psychology* (1887), the *American Journal of Orthopedic Surgery* (1903), and others. Many valuable things are contained in the reports of modern hospitals such as the *Charité Annalen* (Berlin, 1874), Guy's (1836), St. Thomas's (1836), St. Bartholomew's (1865), St. George's (1886), those of Hamburg and Vienna, and the *Bulletin* (1889), and *Reports* (1890) of the *Johns Hopkins Hospital*. The latter is also the best repository of medical history in the United States. The *Index Medicus*, founded by John S. Billings and Robert Fletcher in 1879, and revived by the Carnegie Institution of Washington in 1903, is a monthly bibliography of the world's medical literature.

Glancing at the distribution of medical periodicals in space rather than in time, we find the United States, Germany, France, Great Britain, Italy, and Russia, leading in respect of number or quantity, while, in relation to quality, Germany and France would take the lead. At the end of the fiscal year 1913–14, there had been 8,030 periodicals indexed in the Surgeon General's Library, since 1880. The reason for the large number of periodicals in countries like Russia or the United States is simply the extent of territory, the expansion of modern cities, and the increased number of medical societies resulting from these conditions. The metropolitan journals of the larger cities are usually better than those of States, counties, or territorial districts, as being less provincial in character. Nearly every individualized locality in the modern world, from the Transvaal to the Leeward Islands, from Ceylon to Oklahoma, has or has had some medical periodical. The names bestowed upon these under different conditions often afford good clews to their character and value. A German *Archiv* or *Zeitschrift*, for instance, is apt to be a more substantial production than a *Correspondenzblatt* or *Zeitung*. The historic spirit is sometimes shown in titles like *Isis*, *Chiron*, *Janus*, or *Hippocrates*, and Italy has a large number of periodicals named after her medical men, great and small, *e.g. Cesalpino*, *Cirillo*, *Ercolani*, *Fracastoro*, *Galvani*, *Guglielmo da Saliceto*, *Ingrassia*, *Malpighi*, *Morgagni*, *Orosi*, *Pisani*, *Ramazzini*, *Selmi*, *Spallanzani*, *Tommasi*. The Dutch journals *Boerhave* and *Pieter Camper* are other examples of this eponymic tendency. In a backward country like Spain, whose medical journals are sometimes inferior to those of South America or the West Indies in quality, we encounter titles like *La Caridad en la Guerra*, *El Faro de salud*, *El Porvenir de la veterinaria*, *El Protector de la infancia*, which come from the heart rather than the head. America, in its provincial period, has been responsible for such atrocities as *Balm of Gilead*, the *Divine Science of Health*, the *Drug Mill*, the *Granite State Medical Revolutionist and Hygienic Advertiser*, the *Indiana Scalpel*, the *Lobelian and Rhode Island Medical Review*, the *Medical Waif*, the *New York Dissector*, *Opiophagy*, the *Poughkeepsie Thompsonian*, the *Puget Sound Sanitarian and Prohibitionist*, the *Quarterly Review of Narcotic Inebriety*, the *Quinologist*, the *St. Louis Probe*, the *Southern Homeopathic Pellet*, the *Uric Acid Monthly*, and the *Dental Jairus*.

The tendency toward extreme specialization is indicated in such titles as *Mind* (1876), *Brain* (1879), *La Cellule* (1884), *Tuberculosis* (1902), *Encéphale* (1906), *Névraxe* (1909), *Lepra* (1909), *Epilepsia* (1909), *Heart* (1909), and *Tumori* (1911). Another striking instance of this tendency is the large number of recent periodicals devoted to the psychological and sociological aspects of the sexual instinct in particular, *Vita sexualis* (Leipzig, 1896, Padua, 1901), *Anthropophyteia* (1904), *Mutterschutz* (1905), *Die neue Generation* (1905), *Jahrbuch für sexuelle Zwischenstufen* (1907), *Sexual-Probleme* (1908), *Zeitschrift für sexuelle Wissenschaft* (1908) and such journals of psychoanalysis as Freud's *Imago* (1912).

The principal function of the medical journalist in the modern period is the diffusion of scientific ideas and innovations of value to medicine and the critical or ethical discussion of those sociological movements which have become a part of its "ever-widening sphere," including, of course, actual or pending legislation. If any seasonable advice could be offered to the editor of a new medical journal, it would be: First, give the periodical a suitable, dignified name and let it keep that name, unless it be absorbed by marriage into some other journal. The pedigree of periodicals forms a chapter in itself and the changes rung up on titles have always been a source of perplexity to librarians, bibliographers, and actual readers. Second, aim to make your journal the organ of some reputable society or societies, particularly if it be devoted to a specialty. This will give it a permanent list of reliable subscribers to start with and will help to do away with the enormous duplication or multiplication of medical literature through the reprinting of articles worth indexing in both journals and society transactions. It will also place the editor in better position to reject worthless articles sent in by casual subscribers. In selecting *articles d'actualité*, reviews of current knowledge, and the like, those having a proper historic perspective or unusual qualities of humor or profundity will inevitably be preferred by readers to the routine sophomorical essay, which is forgotten as soon as it is printed. Third, acquire a good corps of competent editorial writers. In regard to editorial policies, it should be borne in mind that for the great mass of mankind, the ethical side of life, the upbuilding of character, is the most important; and that the

origin of religion is not sexuality but the fear of the unknown or the unknowable. The sentimental glorification of crime which occupies such a prominent place in recent fiction has no place in medical literature, properly speaking. A reputable medical editor will not cater to the sidewalk, the brothel, or the smoking room. In regard to the suppression of quackery, patent medicine frauds, and the like, perhaps nothing would seem more specifically desirable than some solidarity between the medical and public press so that the people may have accurate, simple, and non-sensational knowledge about current medical matters of immediate interest to them.

FIELDING H. GARRISON.

Juglans.—BUTTERNUT. The bark of the root of *Juglans cinerea* L. (fam. *Juglandaceæ*), preferably collected in the autumn. The butternut is a medium-sized tree, with short, freely branching trunk and a light foliage of pinnate leaves. The flowers are monecious: the staminate, in lateral drooping catkins; the pistillate few together in terminal clusters. It is a widely distributed tree, growing in the middle latitudes of North America, furnishing a useful cabinet wood, edible nut, and a fair dyeing material. The bark occurs in large quills or curved pieces, about one-quarter of an inch thick. It is of a dark chocolate-brown throughout, the outer surface developing a reddish tinge in time. The outer surface is very little, if at all, fissured or scaly, but is somewhat warty. The inner surface is shreddy with partly detached fiber, in autumn-collected bark, but smooth if collected during the spring or summer. The fracture is weak and soft, but somewhat fibrous, and delicately checkered. It has a feeble odor and a bitter, acrid taste.

It contains a little tannin and volatile oil, fourteen per cent. of fat and a large amount of *juglon*, *nucin*, or juglandic acid, which crystallizes in deep yellow needles and is the active constituent.

ACTION AND USE.—Butternut is a mild cathartic, operating, usually, without pain or irritation, well adapted to continuous administration, and worthy of more frequent use than is made of it. Dose, gr. xv. ad xxx. (1.0–2.0). An extract, extractum juglandis—dose, gr. v. ad x. (0.3–0.6)—is the best preparation.

ALLIED PLANTS.—*Juglans regia* Linn. is the European walnut (*Noyer commun*, Codex Med.); its leaves are the *Folia Junglandis* of the German Pharmacopœia; its oil, the walnut oil of the market. The rind of the green fruits is collected and dried for a stomachic and vermifuge. It contains the *juglon* (*nucin*) above mentioned. The leaves are used for "scrofula, rickets," etc.

Juglans nigra, the black walnut, has probably similar properties to those of butternut.

HENRY H. RUSBY.

Julus.—A genus of Myriapoda, centipedes or "thousand-legged worms." Two species *J. terrestris* and *J. londinensis* have occurred as accidental parasites in the human alimentary canal in Europe.

A. S. P.

Juniperus.—JUNIPER. The fruit of *Juniperus communis* L. (fam. *Pinaceæ*). Juniper fruits are no longer official.

The common European juniper is of variable stature, sometimes attaining the dimensions of a small tree; more often it is a short, broad, pyramidal shrub, with spreading branches; sometimes it consists only of a large flat rosette, with its prostrate or slightly ascending branches lying on and rooting in the ground; by this habit, as well as by its slender, spreading, awl-shaped leaves in whorls of three, and by its larger and more juicy berries, it is easily distinguishable from the common juniper of this country (*J. virginiana* L.).

This shrub grows in nearly all parts of Europe, and is also widely distributed through Central and Northern Asia, as well as in the United States, either native or naturalized. The chief production of the fruit is in Hungary. The "berries" are in reality short fleshy cones, whose three upper scales have become soft and juicy, and coalesced over the three stony seeds; the rudiments of their scale tips may be seen near the top of the fruit. The lower scales are small, dry, and appressed to the axis or peduncle. The berries shrivel a good deal in drying, and were described in the Pharmacopœia as follows:

"Nearly globular, about one-third of an inch (eight millimeters) in diameter, dark purplish, with a bluish-gray bloom, a three-rayed furrow at the apex, internally pulpy, greenish-brown, containing three ovate, somewhat triangular, bony seeds, with several large oil glands on the surface; odor aromatic; taste sweet, terebinthinate, bitterish, and slightly acid."

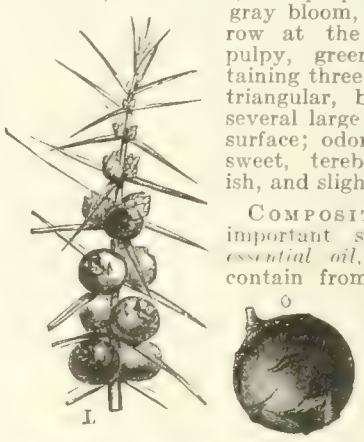

FIG. 3574.—*I*, Juniper Branch, with Fruit attached. (Baillon.) *O*, Juniper fruit, separate. (Baillon.)

COMPOSITION.—The most important substance is the *essential oil*, of which they contain from one-half to one and a half per cent. There is also a large amount of sugar (up to twenty-five per cent. or more), and nearly half as much resin.

The oil consists chiefly of pinene, but its characteristic odor is due to an unknown substance. It is official, and is thus described in the Pharmacopœia:

"A colorless or faintly greenish-yellow liquid, becoming darker and thicker by age and exposure to air, having the characteristic odor of juniper, and a warm, aromatic, somewhat terebinthinate and bitterish taste.

"Specific gravity: 0.850 to 0.890 at 15° C. (59° F.).

"Soluble in about four times its volume of alcohol, forming a somewhat turbid liquid, which is neutral or slightly acid to litmus paper. Also soluble in an equal volume of carbon disulphide."

ACTION AND USE.—Juniper berries and oil have the properties of the terebinthinate substances in general. In small doses aromatic, stimulant to the stomach and intestines, hemostatic; in large ones capable of producing gastritis, nephritis, strangury, etc., as well as nervous disturbances. The chief use is as a stimulating diuretic. A violet-like odor in the urine, and a copaiba-like erythema, are occasionally observed after its administration. Juniper berries are, or ought to be, used in making the *liqueur* called gin, which is alcohol distilled off from their fermented mash and containing their oil. They are not much given by themselves in this country, but might be used as a stimulating diuretic; an infusion or the oil being used.

ADMINISTRATION.—From ʒ i. to ij. (4.0–8.0) may be given at a dose. An infusion of the bruised berries extracts much of the oil, the sugar, etc., and is an acceptable form. The oil may also be given, but is much adulterated with harsher oils from the tops and leaves, and even with oil of turpentine. Dose, gtt. v.–x. (0.3–0.6). There is also a simple five-per-cent. spirit of juniper, the dose of which is fl. ʒ ss. to i., but it is

not much used; and a compound spirit, or artificial gin, offered as a more reliable aromatic than that liquor. Its composition is as follows: Oil of juniper, 8 parts; oil of caraway, 1 part; oil of fennel, 1 part; alcohol, 1,400 parts; water, to make 2,000 parts. Dose, fl. ʒ i.–iv. (4.0–16.0).

Allied Drugs.—Other important products of the genus Juniperus are *savin* and *cade oil*, elsewhere described, besides which there are a number of minor products, mostly oils distilled from the fresh twigs of various species of cedar. Since the properties of these differ in no important respects from those of oil of savin, they need not be further considered.

H. H. Rusby.

Junod, Victor Théodore.—Born at Bonvillars France, on Aug. 5, 1809. After receiving his doctor's degree in 1833 he devoted his attention largely to the study of the effects of compressed and rarefied air upon the human body. The results of these investigations were published in the *Revue médicale*, 1834, in an article entitled: "Recherches physiologiques et thérapeutiques sur les effects de la compression et de la raréfaction de l'air, tant sur le corps que sur les membres isolés." He gained considerable celebrity by his introduction of a method of applying rarefied air, for therapeutic purposes, through the medium of what might be termed gigantic "cups" ("Junod's boot, for example)," thus antedating by more than half a century the "Stauungstherapie" of Bier. He gave the name *hémospasie* to this method. In recognition of the value of his discovery two important prizes were awarded to him—one of the Monthyon prizes in 1836 and the great French prize for medicine and surgery in 1870. Junod is also entitled to the credit of having been the first to invent and put into use cabinets of compressed air. He died in 1881.

Of the numerous essays which Junod wrote on hemospasia the following may be mentioned as among the more important: "Méthode hémospasique," 1843; "De l'hémospasie; Recueil de mémoires sur les effets thérapeutiques de cette méthode," 1850; "Nouvelles considérations sur les effets thérapeutiques de l'hémospasie," 1858; and "Traité théorique et pratique de l'hémospasie," 1875.

A. H. B.

Kairine.—The name *kairine* designates, generically, certain artificially prepared derivatives of chinoline, where either a *methyl* or an *ethyl* substitution has been effected in the chinoline molecule. Of the two kairines, the *methylated*, although the one first made and experimented with, was superseded by the *ethylated* example, for the double reason that the latter is both easier and cheaper to make, while at the same time it is better as a medicine. The ethylated compound *kairine A.*, as it is technically called, is what is now commonly dispensed under the simple name *kairine*. The kairine in medicinal use appears as a whitish crystalline powder, without smell, but of a bitter and pungent, slightly aromatic taste. It is fairly soluble in cold water, freely in hot, moderately only in alcohol and in glycerin, and but sparingly in ether.

Physiologically, the essential action of kairine is that of a powerful but evanescent antipyretic. In the human subject, kairine produces certain and speedy lowering of fever temperatures, with less proportionate derangement in the way of roaring in the ears, headache, giddiness, and gastric distress, than the cinchona alkaloids produce. The action, however, is apt to be attended by profuse sweating during the fall of the temperature, and a decided chill when the after-rise begins. Overdosage has produced profound reduction of temperature, with a condition of general collapse, and kairine has a toxic action on the red blood-corpuscles.

Therapeutically, kairine was used as an antipyretic in febrile diseases, and was the first synthetic substitute for the cinchona alkaloids for such purpose. It has, however, been superseded by newer products of the laboratory, such as antipyrine, which are not so severe in operation. In ordinary cases, four successive hourly doses of gr. viij. (0.5) each will bring down the temperature to 101° F., at which point it may be held by succeeding doses of half the previous dimensions. Kairine may be administered in capsule, pill, aromatized solution, or elixir.

Edward Curtis.
R. J. E. Scott.

Kala-azar. See *Leishmaniasis*.

Kalium. See *Potassium*.

Kamala.—The glands and hairs from the capsules of *Mallotus philippinensis* (Lam.) Muell. Arg. (fam. *Euphorbiaceæ*). This plant is a small tree, growing very extensively through southeastern Asia and Polynesia. The fruit is a small tricoccous capsule, covered with a dense, crimson, velvety surface, consisting of the above-mentioned glands and hairs. Kamala is collected by gathering the fruits and shaking or rubbing them about in baskets, and sifting out the dust-like glands. An inferior variety is obtained by taking the glands and hairs from other parts of the plant. The collection of more or less adhering dirt is inevitable, and advantage is often taken of this fact to adulterate it heavily with earthy matters. Hence the fixing of the limit of ash at eight per cent., which is a very liberal allowance.

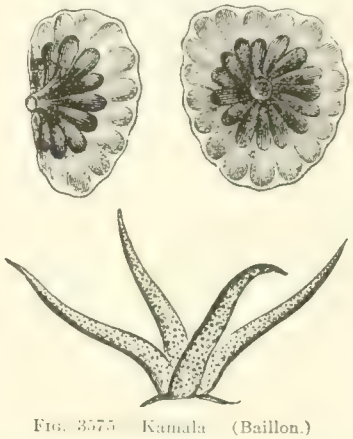

Fig. 3575 Kamala (Baillon.)

It has long been used in India, both as a dye and a a medicine, but its employment as a cure for tapes worm appears to date only from the middle of the present century.

The glands consist of an external capsule containing a yellow fluid, and enclosing from forty to sixty club-shaped cells filled with a homogeneous, transparent, red resin, amounting to about four-fifths of the whole weight of the glands.

Action and Use.—The only purpose for which this drug is employed in medicine is as a tenicide, for which purpose it has considerable value; but the discovery of koosso and pelletierine has displaced it from medical favor, and it is now becoming obsolete. From ʒ i.–ʒ iiss. (4.0–10.0) may be given at a dose.

Henry H. Rusby.

Kaolin is a native aluminum silicate, powdered and freed from gritty particles. It is also known as china clay, because it is an essential ingredient in

the manufacture of porcelain or china. Its chief constituent is the pure aluminum silicate, $H_2Al_2Si_2O_8 + H_2O$. It is official in the United States Pharmacopœia as *Kaolinum*, Kaolin, and is described as "a soft, white or yellowish-white powder, or in lumps, having an earthy or clay-like taste, insoluble in water, and in cold dilute solutions of the acids and alkali hydroxides. When moistened with water, kaolin assumes a darker color and develops a marked clay-like odor" (U. S. P.). It is used as an excipient for some of the metallic salts, and as the main ingredient of the *Cataplasma Kaolini* (U. S. P.), for a description of which see vol. ii, p. 674. R. J. E. Scott.

Kaposi, Moriz.—Born at Kaposvár, Hungary, on October 23, 1837. He was one of Hebra's pupils both before and after he received his doctor's degree from the University of Vienna (1861). In 1875 he was chosen Professor of Skin Diseases, and in 1879 (the year preceding Hebra's death) Director of the

Fig. 3576.—Moriz Kaposi.

Clinic for diseases of the skin at the General Hospital in Vienna. In 1899 he was given the title of "Hofrat." He died in 1902.

Kaposi contributed to medical literature very many larger and smaller treatises on dermatological topics. The titles of some of the more important of these will here be mentioned: "Die Syphilis der Schleimhaut der Mund-, Rachen-, Nasen- und Kehlkopf-höhle," Erlangen, 1866; "Lehrbuch der Hautkrankheiten," 1872 (in association with Hebra); "Handbuch der Syphilis," Stuttgart, 1880; "Ueber Zoster recidivus, hystericus, gangrænosus, epidemicus," 1876; and "Ueber Xeroderma pigmentosum," Vienna, 1882. A. H. B.

Karyokinesis.—See *Cell and Mitosis*.

Kava.—See *Methysticum*.

Keith, Thomas.—Born at St. Cyrus, in Kincardineshire, Scotland, in 1827. He received the degree of Doctor of Medicine from the University of Edinburgh in 1848. He studied under Sir James Simpson, the celebrated obstetrician and gynecologist, and after graduation he became one of Syme's assistants. For a certain length of time he was Physician of the Edinburgh Ear Dispensary. In 1862 he performed his first ovariotomy, without ever having seen the operation performed by any other surgeon. (His friend Spencer Wells had begun to operate four years earlier.) After practising for several years in Edinburgh he removed (in 1888) to London. He died in the latter city October 9, 1895.

Thanks to the great success obtained by Spencer Wells and Thomas Keith the operation of ovariotomy was accepted throughout Great Britain as one of the firmly established surgical procedures. Of Keith's published writings the following deserve to receive special mention: "200 Cases of Ovariotomy," *Edinburgh Med. Journal*, 1867–1874; "Suppurating Ovarian Cysts," *Edin. Med. Jour.*, 1875; and "Cases of Removal of the Uterus for Fibrocystic Tumor," *Lancet*, 1875. A. H. B.

Keloid.—*Synonyms:* Cheloid, scar-keloid, kelos, kelis (Alibert); *Fr.* Chéloïde, tubercules durs, le crabe; *Gr.* Knollenkrebs.

Definition.—A cicatricial-like new growth of the corium, rising prominently above the level of the skin, of variable size, and of a reddish or pinkish color. Its surface is smooth and glistening, its contour is often irregular, band or crab-like—from which it derives its name, χ η λ ή, crab's claw, first applied to it by Alibert in 1817.[1] The disease was previously described as *dartre de graisse*, by Ratz in 1790.[2]

Two varieties were until recent times described, the "true" (*kelis genuina*) and the "false" (*kelis spuria*) according as it was of idiopathic or traumatic origin. As no uniform histological differences between them exist[3] and as the underlying influence giving rise to both forms is unknown, and further, as apparently slight injuries in those predisposed are sufficient to cause them, this distinction is no longer observed.

Symptoms.—When the disease follows a burn or other traumatism of a considerable size, the scar formation, instead of retracting as in normal individuals, becomes unusually prominent and goes on to a varying degree of hypertrophy. In these cases the growth seldom remains limited to the seat of injury but extends beyond the margin and invades the adjacent skin. Some maintain this extension beyond the original lesion establishes its claim to the name of true keloid in contradistinction to hypertrophied scars. It has further been noted that even in susceptible persons all scars do not hypertrophy although the keloid lesions may be multiple as is sometimes observed after variola, acne, etc. When the eruption appears spontaneously, or as many believe, after

Fig. 3577.—Typical Keloid Lesions on the Chest and Arm.

some slight injury as from a scratch or the bite of an insect, it is often first noticed as a slightly elevated, deeply seated, nodular mass of a pinkish color, varying in size from a pea to a lima bean, usually elongated or oval in shape and seldom giving rise to any very marked subjective symptoms. The evolution of the growth takes place slowly, covering a period varying from several months to many years (4); once the

full dimensions are attained it may remain with little or no change for the rest of life, or more frequently involution, either partial or complete, gradually takes place.

In the cases following traumatism which have come under my observation, pain of a burning, lancinating character has not been uncommon and usually in proportion to the area of surface involved. This doubtless is due to the injury of nerve endings or to pressure from the dense structures surrounding them. In color, the growth is usually of a pinkish tint, although varying from a dark red to a whitish color, according to the vascular distribution. The epithelial surface is smooth, tense, slightly glistening, sometimes corrugated in cases of long standing, devoid of lanugo hairs, with capillaries varying in size and number approaching the margin of the growth and sometimes coursing over its surface.

As commonly seen, keloid lesions, whether fully developed or not, present a wide variation in size, in the number of lesions present and to a less extent in color. Thus De Amici[5] observed 318 pin-head to pea-sized lesions symmetrically distributed on various parts of the body, and supposedly of spontaneous origin, in a woman twenty-seven years of age. Chlenov[6] reported a male, aet. 18, with 431 keloid tumors of spontaneous origin. These cases are exceptional, however, and the number usually varies from one to a half dozen, while in size they sometimes attain an area of several inches in diameter and project above the general level from one-sixteenth to one-half of an inch ($1\frac{1}{2}$ to 12 millimeters) or higher

Fig. 3578.—Keloid (Fibromata) following Piercing of the Ears
In the service of Dr. Leon Audain, Port au Prince, Haiti, to whom the writer is indebted for this photograph.

In shape too, the lesions present wide variations, thus on the chest, their common seat, they are usually elongated transversely to the sternum, with spreading, claw-like ends. According to Crocker (*loc. cit.*) one-half of all cases occur in this position. Here, too, they assume their most typical form (see Fig. 3577). Another common site is the lobe of the ears following the piercing for, or subsequent irritation from earrings. In Haiti I was particularly struck by the frequency with which this disease is encountered among the mixed race which inhabits the Island (see Fig. 3578). Next in frequency, according to Darier[7] the upper part of the trunk and neck are affected. In these locations, as well as on other parts of the body, the lesions appear as nodular, irregularly elongated or disk-like elevated, sharply defined placques. In the latter there is often a slightly depressed central area with a prominent rounded margin. On the nape of the neck keloid-like papules assume a peculiar form, which is known as the acne keloid of Bazin[8] or the less euphonious term *dermatitis papillaris capillitii* given to it by Kaposi.[9]

Tenderness on pressure is sometimes complained of even in cases of apparently idiopathic origin and occasionally sharp pains or itching. When complete involution takes place there is left on the site a loose, parchment-like scar. The lesions do not ulcerate or break down unless in strumous subjects or when subjected to repeated irritation. In the latter epithelioma has been known to supervene,[10] although this is not of common occurrence.

Histopathology.—The histological changes found in keloid depend on whether the disease is idiopathic, *i.e.* arising without apparent injury, or whether it follows a traumatism. In the former, the disease may be studied unmodified by extraneous influences; in the latter, extraneous conditions must be taken into account. Thus in traumatism from a burn the complete destruction of the epidermic strata, together with the papillary layer of the corium, will give rise to a histological picture differing from one in which these structures remain intact. In such a case of cicatricial keloid Crocker[4] found in the lower strata of the epidermis a moderate thickening of the rete with the cells of the pallisade layer irregular in shape, although maintaining an even line on the basement membrane below. In another case the same observer found the rete cones and papillæ overlying the tumor flattened or absent, although they were notably enlarged in the parts adjacent. There is, however, no uniformity in these changes and they have also been found in cases of spontaneous origin.[11] All observers admit, moreover, that the essential changes of uniform character are met with only in the middle or upper part of the corium. Here, in the upper or subpapular zone, may be seen a thin layer of loose, connective tissue which is highly vascular, and which in places seems to indicate that it forms an incomplete capsule for the tumor mass. Transverse sections made tended further to confirm this view. In the middle zone, Crocker found in longitudinal sections of an early tumor, delicate, sharply defined fibrils or bundles of fibrils running parallel with the long axis of the tumor, together with fusiform nucleated cells abundantly distributed between them. These cells with free nuclei were found only at the margin of the neoplasm and were most plentiful around the blood-vessels. No hair follicles or glands were found in the tumor, but surrounding this compact mass these appendages were encountered but with their structure partially disintegrated and their lumen filled with round cells. Leloir[12] in more mature lesions found but few nuclei or nucleated spindle cells in the center of the keloid mass. Nor were blood-vessels, coil, or sebaceous glands or hair follicles present in a normal form. These structures were compressed by the collagenous bundles which became greatly hypertrophied and formed a compact mass parallel, for the most part, to the surface. At the periphery these bundles were less densely packed and here again were found nuclei and nucleated spindle cells together with dilated blood-vessels, with swollen, nuclear endothelial cells, which were encased in the fibrous tissue. The hair follicles and glandular structures likewise became more distinct as the margin was approached. Here, too, were found lymphatic lacunæ with enlarged, rapidly proliferating endothelial cells. No changes worthy of note were found in the nerve trunks.[13] This parallel arrange-

ment of the fibers was thought by some observers to be distinctive of the idiopathic form of keloid, but Leloir[13] and others have found the fibers interlacing and running transversely to the long axis of the tumor. The absence of elastic fibers has also been thought by Joseph[1] and others, to be characteristic of idiopathic keloid, but their absence has also been noted by Heidingsfeld[3] in scar tissue and other fibroconnective tissue growths. The involvement of the blood-vessels beyond the tumor line, first observed by Warren[14] has been thought by some to explain why the neoplasm almost invariably returns after excision, and Unna[15] attributes to

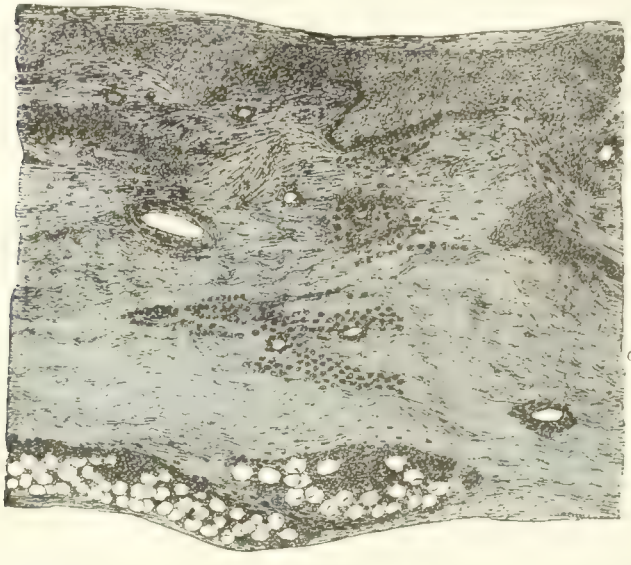

FIG. 3579.—Cicatricial Keloid from the Gluteal Region, following a Burn. *a*, Epidermis. *b*, Malpighian layer. *c*, remains of papillary layer near the border of the tumor; *d*, keloid tissue. The cellular infiltration around the blood-vessels is also indicated at several points. (From an original drawing by Dr James M. French.)

this the frequent extension of the growth by claw-like projections at the periphery. In addition, giant cells have been found by Dénériaz.[16] We may therefore conclude, after more than a century during which keloid has been studied, that its histopathology is well understood and that the three forms once recognized by pathologists are now either eliminated from the keloid group or regarded as one process.

Etiology.—The ultimate or underlying cause of keloid has not been determined. It is known that it occurs most frequently in the negro and in dark skinned races, and that in certain individuals it occurs after injuries to the integument, such as cuts, burns, etc. Furthermore, Welander[17] observed it to occur after tatoo marks avoiding the blue and selecting only those parts in which red pigment had been used, from which he infers that it may be due to some special local irritant or poison. It is sometimes observed in long-continued suppuration as in the so-called acne keloid, more rarely in pustular syphilis (Taylor, Brocq, Wilks) and in variola (Goodhart) which would lead one to believe it may have a microbic origin. Again, the presence of giant cells and other features led Tillbury Fox,[18] Hyde,[19] and Jadassohn[20] to regard it a tuberculide.

A committee, appointed by the Clinical Society of London in 1880 to investigate the cause of keloid, reported, while it was not prepared to deny the possibility of a spontaneous origin, yet found that it nearly always followed some injury often of a trifling nature, such as the bites of insects, prickly heat, blisters, etc.[21] It is now thought by most observers that slight, often unheeded injuries or the presence of certain microorganisms in those predisposed are sufficient to set in action this neoplastic process. This hypertrophy of the collagen in the corium which occurs either idiopathically or on the slightest injury constitutes, therefore, the special feature in the formation of keloid.

Hebra,[22] Wilson,[23] and others have observed cases in which several members of a family were affected. Bryant (cited by Crocker[1]) mentions a case in which keloid was present at birth. While the disease occurs at all ages it is most common in adults and is seldom met with in old age. Sex has no appreciable influence.

Prognosis.—The unfavorable prognosis given to keloid has been somewhat modified during the last three or four decades by the observations of several clinicians of extended experience. Notably that of Jonathan Hutchinson, whose recognized acumen as a clinical observer lends exceptional value to his conclusions. I believe it well to bear in mind, however, that in his generalizations on keloid[24] he makes no distinction between keloidal scars and the so-called idiopathic keloid of Alibert. He found that in young people the disease, after developing for months or years, remains stationary for a variable time, then begins to subside and in a large number of cases disappears completely. This *vis medicatrix naturæ* is more noteworthy since, as will be shown, our treatment thus far has not been uniformly successful. It is also believed by many that keloid developing in scar tissue is less unfavorable than when the disease appears without apparent traumatic disturbance. My own observations lead me to incline to this view, and while macroscopically and histologically no essential differences are found between traumatic and spontaneous keloid, the prognosis, I believe, differs. In the former, involution is slow but ultimate disappearance is not uncommon while in the latter the disease remains longer and its complete involution is remote, if ever it occur. The line of demarkation between hypertrophic scars and keloid is sometimes exceedingly difficult to draw, but for purposes of prognosis it is necessary to take into account the degree of disturbance necessary to set up the keloidal process, or in other words, the greater the natural resistance to this process the less liable is the disease to be permanent.

The danger to life from keloid is considered to be less than was the case at one time. True, after excision the growth is known promptly to return and usually covers a larger area than it originally occupied, but it is extremely rare to see the lesion break down, suppurate, or degenerate into malignancy. Of course, in positions subjected to constant irritation from rubbing by clothing or other irritation the latter might take place, as sometimes occurs in parts not keloidal.

Treatment.—From the foregoing it will be seen that no very satisfactory means of getting rid of keloid has been found. Removal by the knife if attempted should extend beyond the margin of the growth, the object being to remove the implicated blood-vessels which are known to extend beyond the tumor line. In small growths this might be done with a possibility of its being successful. Hardaway[25] advised electrolysis, but experience has demonstrated this to be only partially successful. Linear scarification has been strongly recommended by Vidal[26] and others. I have seen improvement and in some cases a marked diminution in the tumor by this method. To be effectual the incisions, preferably after local anesthesia, should

extend deeply through the entire thickness of the mass and also two or three millimeters beyond the margin. Cross and oblique sections should be made. The cuts should be about two millimeters apart. Repeated operations are necessary and Vidal continued the scarifications until a soft, smooth scar resulted or the patient, as often happened, disappeared. But this method too does not invariably nor wholly cause the growth to disappear. The Röntgen rays in recent years have been used and some favorable results are reported. From radium even better and more uniform results might be expected, because of its easier manipulation and less liability to indolent burns so frequently seen when the *x*-rays have been used unskilfully, rendering the condition more deplorable than before treatment. If *x*-rays are used the exposures should be short and a sufficient interval allowed to avoid a cumulative effect.

Internally thiosinamin has been recommended but I have found it inert in the cases thus treated. Hypodermically, more promise was entertained of its efficacy, but again, I am not aware of any brilliant results recorded.[27] The injection of necrotic substances such as creosote have been employed by Balzar and Mousseaux,[28] causing necrosis and final destruction of the growth. Compression is also recommended either by an elastic bandage or with mercurial plaster.

From the foregoing it may be inferred that of the various measures occasionally one will be found that seems to possess a curative effect, yet there are none that are uniformly successful. It is therefore expedient to select the form of treatment which seems best suited to the special case. When small, pea to bean sized, it might be removed by the knife, the incision going about five millimeters beyond the tumor; if vascular, as evidenced by its red color, linear scarifications followed by mild antiseptic applications and firm pressure are indicated. When covering a large area undoubtedly the *x*-rays offer the method of choice. WILLIAM THOMAS CORLETT.

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Kentucky Carlsbad Springs.—Kentucky.

POST-OFFICE. –Dry Ridge. Hotel.

ACCESS.—Viâ the Queen and Crescent Railroad.

The springs are situated on the Covington and Lexington Turnpike, just thirty-five miles from Fountain Square, Cincinnati, Ohio. The water was accidentally discovered during the boring of an artesian well. The water was struck at 1,100 feet underground and rose in the well 700 feet. The following analysis was made by W. Simonson:

	Parts per Million	Grains per U. S. Gallon
Total dissolved solids	4000.00	234.07
Calcium carbonate	178.0	10.40
Magnesium carbonate	104.4	6.09
Sodium sulphate anhydrous	239.3	14.07
Sodium bicarbonate	75.0	4.30
Sodium hydrosulphide	88.50	5.17
Potassium sulphate	100.8	5.88
Ferrous sulphide	12.5	.73
Strontium carbonate	8.5	.50
Lithium carbonate	5.2	.30
Sodium bromide	1.22	.07
Sodium chloride	3138.0	183.23

The water is entirely free from organic matter. It looks very much like ink, being of a dark greenish color. It is beneficial in disorders of the stomach, kidneys, and bladder, and in catarrhal and rheumatic troubles. EMMA E. WALKER.

Kephir is the product resulting from the action of certain yeasts upon cow's milk. By the influence of a lactase existing in the yeast the milk sugar, or lactose, is transformed into a mixture of dextrose and galactose. These monosaccharides then undergo alcoholic fermentation and lactic acid fermentation owing to the presence of certain microorganisms. The quantity of alcohol formed varies between one and 3.5 per cent., and that of lactic acid from one to two per cent. Another change occurring in the mixture is the partial transformation of the proteins to proteoses and peptones, so that the final result of the chemical changes results in the production of a substance of easy digestibility with significant quantities of alcohol and lactic acid present. F. P. UNDERHILL.

Kerasin.—See *Cerebrosides.*

Keratin is the basis of the epidermal structures of the body such as skin, hair, nails, horns, hoofs, feathers, wool, etc., and belongs to the group of proteins designated albuminoids. Its chief characteristic is its great insolubility in the ordinary reagents. It is not dissolved by water, alcohol or ether but is slowly soluble in water on heating to 150–200° C. On heating with alkalies it also dissolves. It is not dissolved by gastric juice or pancreatic juice and it gives the

xanthoproteic reaction and Millon's test for protein although the latter may not be characteristic. Keratin may also be present as neurokeratin in the brain and nerves.

It is probable that there are a number of keratins differing slightly chemically according to origin, thus from the keratin of sheep's hoofs about two per cent. of phenylalanine may be obtained whereas in the keratin obtained from hair and feathers this amino acid is not present. The keratins differ chiefly from other proteins in their large content of sulphur which exists in the form that may be split off as cystine. As a rule, keratin yields the same amino acids on cleavage that are characteristic for other proteins.

FRANK P. UNDERHILL.

Keratitis.—See *Cornea, Diseases of.*

Keratohyalin.—See *Cornification.*

Keratosis Follicularis.—*Synonyms:* Psorospermosis Follicularis Vegetans, Keratosis Vegetans, Ichthyosis Sebacea Cornea, Ichthyose Noire Cornée, Acné sébacée cornée, Darier's Disease.

DEFINITION.—Keratosis follicularis is a hypertrophic affection, characterized by pinhead- to pea-sized horny plugs, embedded in funnel-shaped dilatations of the pilosebaceous follicles.

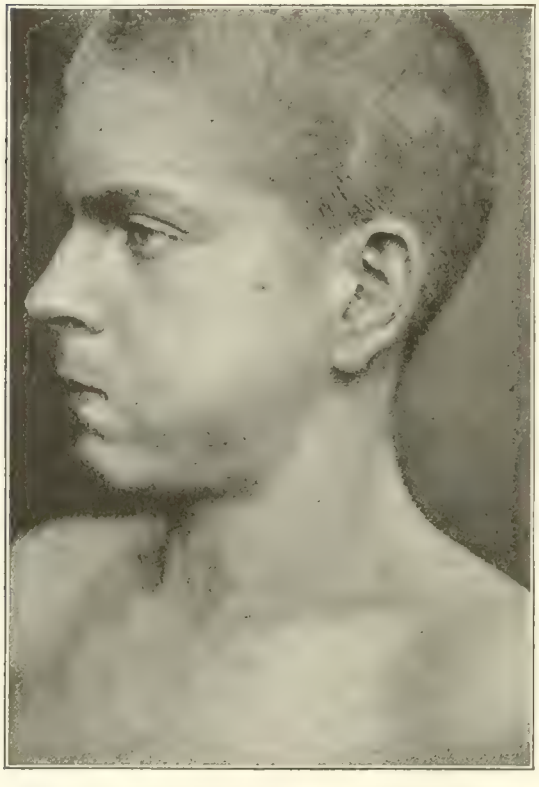

FIG. 3580.—Keratosis Follicularis. (Dr. William H. Mook's collection.)

This rare affection of the skin was almost simultaneously described by White and Darier. It had, however, previously been recognized under other names (Ichthyosis follicularis, Morrow) although positive histological proof was lacking of their being identical. The interesting observations of Darier that the striking cell forms found in the skin lesions which he at first conjectured were parasites resembling coccidia, resulted in very careful examinations on the part of many investigators, as well as the reporting of numerous cases. It has turned out, however, that White and Bowen were correct as to the nature of this disease and that Darier's protozoan interpretation was wrong.

SYMPTOMS.—The primary efflorescences appear in the form of pinhead-sized papules, more or less raised and covered with greasy scales that vary in color from a dirty yellow to a brown black. These scales cling together with considerable tenacity; when removed they frequently show on their lower surface a dingy, conical projection that does not vary much in color from the normal skin and is not unlike the projection of keratosis pilaris; with some difficulty the projection may be rubbed away, and it sometimes corresponds with the orifice of the sebaceous follicle and always with the funnel-shaped depression of the upper skin which is independent of the follicle. These primary lesions become expanded to the size of a lentil by the deposit on their peripheries of new dirty-gray or black-brown foci, and they run together into large irregular plaques bordered by disseminated primary efflorescences; the surfaces soon appear more or less warty. The plaques growing out of them may also attain considerable size—in one case reported by Darier, these hill-shaped efflorescences, devoid of epidermis ran together on the pubes into large tumors separated by deep furrows; they were bright red in color and showed numerous crater-like orifices containing secreted pus which emitted a decided odor. Besides these peculiar changes there are present, in almost all the recorded cases relating to the scalp, fatty yellow to brown, and often slightly warty, masses of scales penetrated by hair. Sometimes these were reddened, moist, and excoriated, at other times they were not essentially changed. On the face the parts chiefly involved are the temples and the cheeks around the alæ nasi. The dorsal surfaces of the hands, feet, and fingers appear at times to participate in the disease process. The nails are almost habitually involved whether like changes occur in the fingers or not; they are generally striated longitudinally and rent or fragmented at their free edges. On the trunk, especially the sternal, the interscapular, and the sacral regions are affected. In some instances the palms and the soles show a considerable callous formation. In the course of the affection the manifestations exhibit distinct exacerbations and remissions. This condition at times almost disappears but no instance of actual recovery has yet been reported. At the sites of many of the follicles the hyperkeratosis breaks down with ulcer formation while the whole of the vegetating mass may be bathed in mucopurulent discharge. The subjects of the malady often emit an offensive odor. Bowen suggested the possibility of the lesions becoming epitheliomata because of the persistence and development of the disease; and later Wende recorded a case that resulted in multiple epithelioma showing more than 150 malignant growths of the three different clinical varieties, superficial, deep, and papillary. (See Plate XL, Fig. 1.)

ETIOLOGY.—The time of its appearance is variable, though it generally occurs late in childhood, or early in youth, but in some cases it is deferred to a period between the ages of twenty and thirty-five years. In a case of Hallopeau's, the disease first appeared in the sixty-first year. MacLeod first called attention to the fact that heredity plays some part in the etiology, and his opinion has been supported by many observers. Boeck reports it in a father and his sons. White, in a father and daughter. Trimble observed five cases in one family in three generations.

The bacteriological examinations have been constantly negative. The theory advanced by Darier,

Fig. 1.

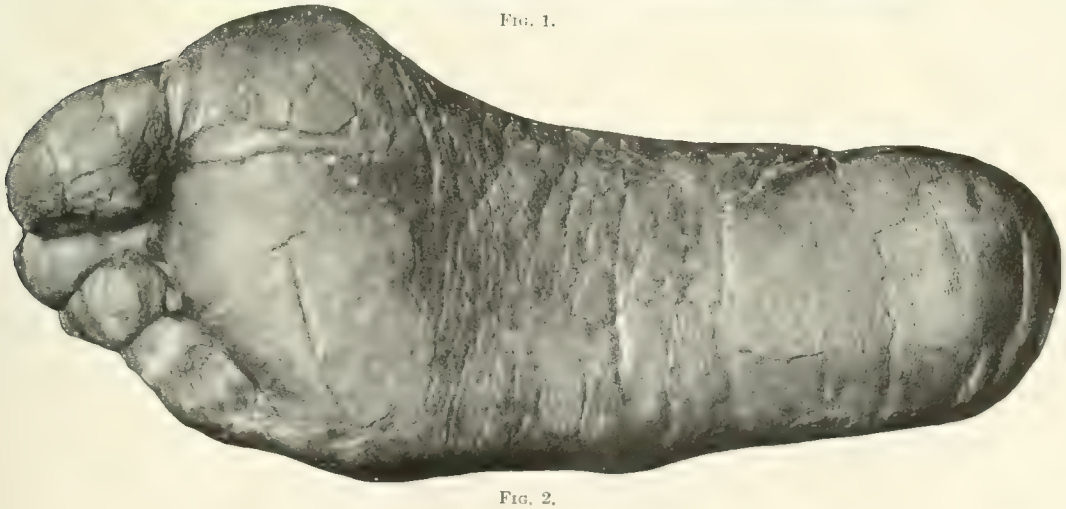

Fig. 2.

KERATOSIS

Fig. 1.—Keratosis Follicularis. The lesions are abundant and have coalesced into papillomatous masses. (Dr. William H. Mook's collection.)

Fig. 2.—Hyperkeratosis of the Sole of the Foot following Eczema. (Author's collection.)

and later elaborated by Wickham, that this variety of keratosis was due to the presence of psorosperms, or coccidia, has been abandoned even by these authorities themselves; consequently, the precise cause of the disease still remains wholly in the dark.

Pathological Anatomy.—Upon this point all authorities have reported similar results. The changes chiefly occur within, or in close proximity to, the mouths of the pilosebaceous excretory ducts. These are dilated so as to form funnel-shaped openings, which are filled with a mass of horny cells continuous with the scales that cover the follicular opening. The wall of the follicle is composed of thick, horny layers limited to the rete cells. The epidermis generally appears more or less thickened. The rete Malpighii appears as if hypertrophied; the interpapillary prolongations are lengthened and press firmly against the corium. The epidermis and the horny masses constituting the summit seem partly to consist of horny lamellæ of normal appearance, but heaped up one upon another in great piles, partly composed of abnormally horny cells in which the nuclei are well preserved. Typical of the affection is a defective formation in the lower layers of the rete Malpighii, in association with degenerated cells, lymphoid cells, and fibrin, and connected with the degenerated processes of the rete cells. There also appear in the epidermis numerous peculiar elements which Darier has designated as psorosperms. These round bodies he describes are corpuscles which show a more or less clearly defined cell of granulated protoplasm, surrounded by a refractive membrane. Almost all authorities at the present time believe that the psorosperms of Darier are only degenerative forms of the rete cells and that they are not an exclusive phenomenon of keratosis follicularis, but also occur in lichen ruber and lupus erythematosus. Darier, however, firmly contends that their abundance constitutes a characteristic element of the disease. Besides these changes, there is an increased amount of pigment in the contents of the basal cell layer at the periphery of the efflorescence, while the horny layer contains little or no coloring matter; it shows, however, more or less granular pigment. In the region of the elongated papillæ of the corium there is generally found a moderate infiltration, which has been described as consisting of plasma, connective-tissue or mast cells, and leucocytes. Bowen's conjecture that the lesions might become malignant is apparently supported by Darier's histological findings which he considered as suggesting those of epithelioma, but all authorities describe this affection as non-malignant; nevertheless, in Wende's case which began as a benign keratosis follicularis as shown by the microscopical findings, the affection while under observation developed into a condition of epithelioma.

Diagnosis.—The diagnosis of a well-developed case presents few or no difficulties. One of the diseases it early resembles is keratosis pilaris, but the presence of the latter on other characteristic locations is a differential point. Another disease easily differentiated is acanthosis nigricans which involves the mucous membrane, presents warty deeply pigmented growths and is associated with visceral involvement. It differs from molluscum epitheliale in being more generalized, and does not exhibit an enucleable mass containing the so-called molluscum bodies. This disease bears close resemblance to some types of ichthyosis, but careful study enables one to differentiate it; ichthyosis being congenital, the former being acquired.

Prognosis.—The prognosis is unfavorable, as shown in nearly all the cases heretofore reported, in which the disease has lasted for years without undergoing spontaneous involution. The general health of the patient is unaffected, other than in the way of subjective sensations.

Treatment.—Heretofore little benefit has been derived from therapeutic measures. A heightened irritability of the skin limits the use of the common remedies employed in hyperkeratosis, such as salicylic acid, resorcin, pyrogallic acid, and chrysarobin. Sulphur, especially that form known as Vleminckx's solution, is applied to the affected places, later they are scrubbed with soap and water, carefully dried, and then covered with some soothing application. In general, the remedies for eczema seborrhoicum should be tried, as there are striking analogies between the two diseases. Marked improvement has been recorded from thermocauterization by both the Paquelin and the galvanic cauteries. Recently, many have announced that by the use of *x*-ray the lesions can be made to disappear entirely although there is a tendency to relapse; a few instances of cure have been recorded.

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Keratosis Follicularis Contagiosa.—This type is the same as that which was formerly characterized by the name of acne sebacea cornea, an appellation originally bestowed upon it by Dr. Prince A. Morrow; the term contagiosa was added by Dr. H. G. Brooks, the first to describe this particular association.

The type begins with small, black points, usually on the elbows and knees, afterward extending up the arms and thighs and finally invading the greater part of the surface of the body. The face may also be affected, while the scalp remains free; the distribution is symmetrical. The black points soon become prominent. Coupled with these are large, sharp-pointed comedones around which papules are finally developed, some of which become inflamed. Most of the cases reported occurred in children although a few sporadic cases have been reported in adults. Clinically it somewhat resembles Darier's disease but histologically psorosperm bodies are not found in the lesions. The lesions mostly, although not exclusively, occupy the pilosebaceous follicles, and consist essentially of a hyperplastic proliferation of the epithelial cells, combined with modification of the process of keratinization which allows them to preserve their vitality during a longer period than that pertaining to inflammatory exudations. The lower layers of the stratum granulosum are primarily attacked, not only at the level of the sebaceous follicles, but also in the excretory duct of the sudoriparous glands, and in the interpapillary prolongations of the epidermis. No microorganisms were found in the cases quoted by Brooks. The contagious nature of the disease was simply conjectured on account of its distribution and for the reason that it affected the entire family at the same moment.

Grover W. Wende.

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Keratosis Palmaris et Plantaris.—*Synonyms:* Keratoderma palmare et plantare hereditarium, ichthyosis palmaris et plantaris, tylosis palmæ et plantæ, symmetric keratodermia.

Definition.—Keratoderma of the palms and of the soles is an affection characterized by a thickening of the horny layer, leathery in consistence, yellow or brown in color, and more or less symmetrical in distribution.

From a purely clinical point of view, this variety of keratoderma is a definite term applied to conditions of thickening of epidermis from several and distinct causes—for example, lupus which is always accompanied by thinning of the epidermis is frequently associated with hyperkeratosis at these sites; while dry eczema which is usually accompanied by extensive desquamation of the increased epidermal tissue, at these sites often produces a keratoderma. Clinically, therefore, keratosis in default of histological characteristics is strictly an hypertrophy of the horny layer of the skin. It is generally maintained, however, that the palms and soles are regions of specialized dermal structure and not comparable to other parts of the body. By reason of their situation, and the necessary exposure to the influence of external irritation, the hands and feet are affected by a given disease in a manner different from other parts of the body. There can be no doubt that in the future, no matter what classification is adopted, the diagnosis will be founded upon characteristics revealed by the microscope. As keratoderma is the outcome of different conditions, some general and diffuse and some local, a satisfactory classification is extremely difficult. It may be congenital; it may be due to psoriasis, eczema, lichen planus, pityriasis rubra pilaris, syphilis in either the secondary or tertiary stage, and even gonorrhea.

Congenital Type Palmar and Plantar Keratosis.—As a rule, the disease is observed during the first weeks of life, yet its development is often delayed until the close of the first year, or even as late as the third or fourth year. It begins as a diffuse redness of the palms and soles; later it becomes scaly and the redness disappears, when the condition is established and the epidermal thickening commences. At certain points it may become circumscribed and resemble a callus (Fig. 3581). In the folds of the flexures there are often deep rhagades. In extreme cases the horny layer is ploughed into fissures of a greater or lesser depth. The abnormal epidermal thickening of the involved areas generally stops abruptly, conforming to theoutline of the palms, but quite often it extends to the back of the fingers. The horny carapace sometimes preserves its natural color—an amber yellow—or may become gray or black by the penetration of dust. Its surface is wrinkled, and it desquamates in the form of irregular masses producing a mosaic-like appearance or a rough surface resembling the bark of a tree. It may sometimes affect other parts of the body, such as the knees and elbows. Once established, the disease continues indefinitely and is likely to be worse in winter.

In considering acquired palmar and plantar keratosis the several different forms demand separate description.

Hyperidrosis Type.—Keratosis of the palms and soles, developing in adults, due to hyperidrosis which latter is probably caused by some central neuroses, and it is also influenced by weather. This variety may also be due to toxic causes such as alcohol, tobacco, or foods, and even be due to constitutional conditions. The palms or soles, or both, are at first erythematous, cool, and damp; later hyperkeratosis appears superficially on the palmar or plantar surface of all the digits and on the anterior and inferior extremities of the metacarpus or metatarsus; being especially pronounced near the summit of the thenar eminences. On the feet the keratosis is better defined than on the hands. The keratinized patch is usually surrounded by an erythematous border; upon removal of the horny layer even the elongated papillæ give evidence of hypertrophy. There is no pain except when fissures are present; the affected areas being usually soft because moistened by the effused sweat. The nails are often affected. The condition varies with that of the general health, and by treatment. Patients complain bitterly of soreness and discomfort when the hyperkeratosis is excessive.

Arsenical Type.—Hyperkeratosis is one of the principal effects of the prolonged ingestion of arsenic; this variety is most marked on the palms and soles, though it may involve the skin elsewhere. In the

Fig. 3581.—Congenital Keratoderma of the Palm of the Hand. (Dupré et Mosny.)

not very rare mild variety the palms and soles become slightly dry and the epidermal markings coarse and exaggerated, with here and there small readily removed white horny granules about the size of a pinhead. In the more pronounced forms which appear only after arsenic has been taken for a long time, the horny layer becomes uniformly thick, compact in structure, amber in color, very firm to the touch and without rhagades; at other times, however, it becomes grained or shagren-like. With hyperidrosis the parts are soft and moist; should the sweat be normal, the hyperkeratosis will be found usually dry.

Eczema Type.—Palmar and plantar keratosis occurs most frequently in association with eczema. It may attack the hands alone or more rarely the feet; it often attacks all the extremities. It may be symmet-

rical but usually one side is more affected than the other. Itching, is a constant symptom, although at times it may be slight. Palmar and plantar keratinized eczema is a disease especially belonging to old age. The hyperkeratosis as the result of eczema of the soles presents about the same characteristics as that observed in the palms, although the hypertrophy of the horny layer is more marked (Plate XL, Fig. 2). It forms a hard, gray, more or less black shell around the heel, displaying a great number of quadrangular crevasses characterized by long and deep rhagades which run in various directions and cause considerable discomfort to the patient. While hyperkeratosis has been rated as a frequent complication of eczema, nevertheless the percentage of occurrence is small.

Psoriasis Type.—Palmar and plantar keratosis the result of psoriasis occurs only when psoriasis is found on other parts of the body; it is rare for psoriasis to occur on palms and soles alone. It develops at the periphery of the lesions; the edges alone showing hyperkeratosis in the form of a distinct border surrounding the desquamating psoriatic lesion which by splitting produces whitish worm-eaten looking spots characteristic of this type.

Lichen Planus Type.—Keratosis of the palms and soles due to lichen planus is rare and does not always accompany this disease. It is found alike in the local and generalized, and in the acute and chronic forms in all of which the palms and soles are covered with papules having an hypertrophied epidermis. Later, in the more chronic cases these surfaces are covered with a thick, horny, yellow translucent layer.

Pityriasis Rubra Type.—In this rare disease which is never confined to the hands and feet, the keratosis affects only these parts. The palms and soles are at first scaly but subsequently become hyperkeratotic.

Syphilitic Type.—Here the keratoderma differs with the stage of the disease. During the secondary stage it shows itself especially on the palms of the hands. The older the lesions, the thicker becomes the epidermis when desquamation slowly takes place. In the tertiary stage, when palmar syphilides are more frequent and extensive, the areas often become infiltrated and covered with a thick, horny epidermis, frequently raised like collarettes cut by deep rhagades.

Gonorrheal Type.—Under the name of keratoderma blennorrhagique, Vidl, Jacquet and Ghika, Chauffard, Simpson, and Sabotka have described this affection of the skin, accompanying gonorrhea. This form of keratosis occurs especially in the course of repeated attacks of gonorrhea with severe articular and general manifestations; both palmar and plantar surfaces are usually involved although it may appear upon the trunk. In a typical case, the epidermis is thickened with slightly elevated dark brown nodular patches with uneven surface of variable size, one-half to three centimeters in diameter; the intervening areas are covered with a naturally colored parchment-like thickening of the epidermis.

Etiology.—Heredity is an important etiological factor in only the congenital type in which, like ichthyosis, keratosis tends to attack the same sex in a given family. When acquired, keratoderma may be associated with disturbance of the heart, lungs, nervous system, or general bodily health; marked tachycardia or bradycardia may be present. One of the common causes in the production of keratoderma is the remedial use of arsenic; it has even resulted from drinking water and, in England, beer which contained the drug. Local irritations play a very important part, as keratosis from contact with acids or alkalies, or from traumatism such as the habitual use of tools. Another cause is the inflammatory change in certain dermatoses as eczema, psoriasis, syphilis, and lichen planus. A remarkable etiological factor is the infection of gonorrhea that has become constitutional.

Pathology.—The pathology, while meager, corresponds in general with that of callosities. Besnier and Balzar have noted that the horny layer for a great part of its depth is infiltrated with eleidin; that there is an increased thickness of all the layers of the epidermis; that the papillæ are sometimes elongated and thinned and at other times thickened and shortened by reason of the multiplication of the cells which compose them; and that beneath this layer of shortened papillæ there is found in many cases, a hyperemia of the upper layer of the derma. The histological findings reported by Brooks and Roberts in an article relating to the action of arsenic on the skin were corroborative.

An examination of sections of the lesions affected by acute erythematous hyperkeratosis showed that the pathological changes presented an hypertrophy of the epidermis, especially of the stratum mucosum. The cells were large, with well-proportioned nuclei; they had clearly defined walls, and revealed very distinct prickles. There was no edema or mitosis. An accumulation of horny cells appeared in the upper layers of the epidermis. If the lesions had been subjected to the influence of arsenic, the vertical cells drooped and leaned to one side, were filled with pigment granules, and the nuclei were changed in shape. Later, the process of degeneration set in, ending in atrophy. The rete had almost entirely disappeared and at times only one or two rows of cells remained behind; the stratum granulosum and stratum lucidum showed marked evidence of degeneration. The epithelium was reduced to a very thin layer, with the entire disappearance of the stratum lucidum, which showed horny plates. In the later chronic stages the whole of the epidermis was filled in with pigment, producing a black discoloration. The excretory portion of the sweat glands was stained black by osmic acid, leading to the conclusion that the amount of fat had been increased; finally the sweat and sebaceous glands showed atrophy.

Diagnosis.—Keratosis palmaris et plantaris due to eczema is differentiated by the presence of the well-defined inflammatory symptoms, by the presence on other portions of the body, by the variability in symptoms, and by the limitations of the plaques. Where due to psoriasis it is distinguished at the beginning, by the distinct papules of psoriasis and, later, by the marginate disposition of the keratosis. Palmar and plantar keratosis due to syphilis is always to be considered with caution, and especially to be distinguished from psoriasis of the same regions. The differences lie in the multiplicity of the lesions in syphilis, their redness, the more marked infiltration of the border, and the presence of bulky and horny scales. The external appearances of arsenical keratoderma are very characteristic; almost invariably there will be found a symmetrical hyperkeratosis of the hands and feet, with a horny layer which has an almost uniform thickness, supple and without fissures.

Prognosis.—Congenital keratoderma is most uncomfortable as well as incurable. Sometimes it is so severe as to interfere with all manual labor which requires delicacy of touch. All types of this disease that are secondary manifestations are curable, although, under the most favorable circumstances, they are exceedingly resistant to treatment, and require long periods for their permanent relief.

Treatment.—For the hereditary type of keratoderma, arsenic in large doses, particularly the arsenite of sodium, has been recommended by Brocq. There are, however, many misgivings among physicians as to its virtue. The only practical treatment is local—the attempt should first be made to cure the rhagades by proper applications and by the removal of the horny masses. Afterward such measures should be adopted as will tend to arrest the persistent tendency to reproduce layer after layer of a horny character.

Hyperkeratosis due to arsenic is of course cured by discontinuing the use of the drug. When it is due to eczema the treatment consists in suppressing the local or general influence which has produced that disease. When it is the result of occupation or of contact with irritating substances, the occupation must be abandoned and the substances avoided. The internal treatment indicated for lichen planus and for pityriasis rubra pilaris should be carried out when keratoderma is associated with either of these affections. The local treatment in all types is about the same—prolonged maceration of the parts, followed by shampooing with green soap, supplemented by strong plasters of salicylic acid or resorcin. One of the best keratolytic ointments is made up of eugallol half a dram, oil of cade half a dram, to the ounce of base. Mercurial plasters may also be used to advantage. A very good treatment is recommended by Unna; it consists in dressing the affected part with compresses immersed in a two-per-cent. solution of resorcin, and then enveloping these with rubber tissue. These dressings are to be worn at night, removed in the morning, and followed by an application of salicylic-acid ointment. The *x*-ray gives very satisfactory results in the congenital as well as the several acquired types.

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Keratosis Pilaris.—*Synonyms:* Cacotrophia Folliculorum, Folliculitis Rubra, Keratosis Follicularis, Keratosis Suprafollicularis, Lichen Pilaris, Ulerythema Ophryogenes, Follicular Xeroderma, Ichthyose ansérine des Scrofuleux.

DEFINITION.—Keratosis pilaris is a hypertrophic affection of the skin not uncommonly seen on the outer anterolateral and posterolateral aspects of the thighs and arms, due to the formation of small horny elevations about the apertures of the hair follicles.

This form of hyperkeratosis was originally described by Hyde and later by Brocq as a separate disease. It had previously been regarded as one of the manifestations of ichthyosis, with which it often coincides, but from which it differs in localization, histopathology, and evolution. This condition—one of horny plugs or filiform spines in the hair follicles—is a feature of many dermatoses as is indicated by its prolific nomenclature. The many synonyms are due to a modification of the common name by adjectives to express the varied dermatoses with which it is associated, thereby apparently indicating many different conditions.

SYMPTOMS.—In its most common form, keratosis pilaris is characterized by pointed pinhead-sized elevations, one-half to one millimeter in height, developed around hairs. These horny plugs are usually of a dirty-white or grayish hue pierced by a lanugo hair from the follicle about which the abnormal condition exists. These plugs can be easily picked out, leaving a depression without any apparent inflammatory appearance. The skin between the papules is harsh and dry, and may at times present the appearance of an ichthyosis. In more marked cases the lesions are distributed without order on a normal or an ichthyotic skin. (Fig. 3582.)

It is not uncommon for the milder forms to be so slight as to escape recognition because of a rough resemblance to goose flesh; in other cases the lesions

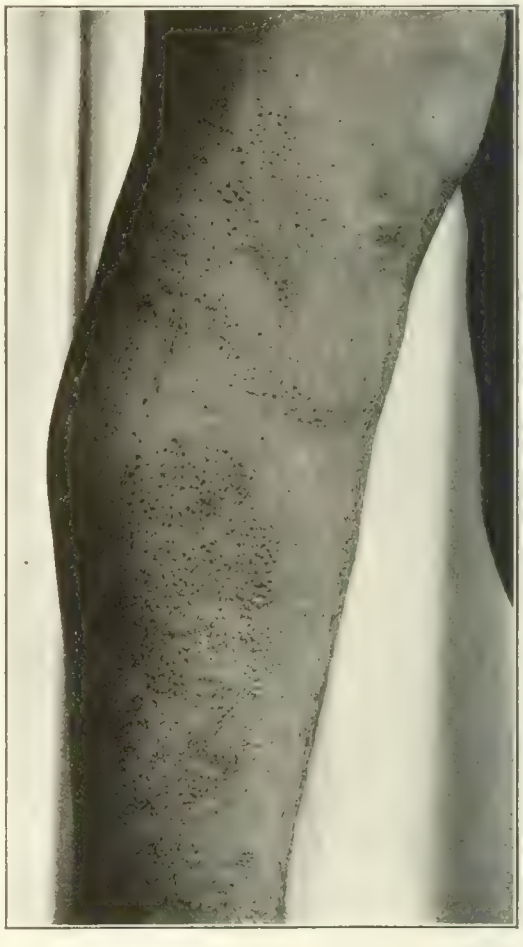

FIG. 3582.—Keratosis Pilaris. (Courtesy of Drs. Fordyce and MacKee.)

are very pronounced and may be distributed over a considerable part of the body. Its development is slow and indefinite, more marked during cold weather which gives rise to sluggish action of the sweat and sebaceous glands. The hair assailed is more or less atrophied, is seen to pierce each papule, and may be twisted; its caliber is often unequal.

The middle portion of the back of the arms, as well as the forearm, the buttock, and the front of the leg above the knees, may be involved. The flexor surfaces and the middle of the trunk alone remain free. On the face the eruption presents peculiar characteristics; the prominences are very small and confluent, their presence suggesting congestion. Brocq describes a type the favorite seats of which are the face and the forehead, where it forms two red plaques above the internal third of the eyebrow, occupies either the internal or external front of the ear, or is disposed in a

vertical plaque reaching from the temple to the angle of the jaw. The space between the eyebrows or the middle of the chin, in very pronounced cases, may be involved. The scalp presents desquamation like that of seborrhea. Brocq has observed, in connection with keratosis, the formation of circumpolar papules and cicatricial atrophy, both of which he connects with moniliform aplasia of the hairs of the head and body. This condition corresponds to the ulerythema ophryogenes of Taenzer and Unna and the xeroderma of Besnier.

Etiology.—This disease is shared in greater or lesser degree by a majority of the people. It is usually attributed to lack of bathing, but may occur in persons who scrupulously observe hygienic rules. It may appear before puberty, although, as a rule, it does not. It is wanting where the hairs are atrophied, and it becomes attenuated and finally disappears with advancing age, the pilar system having become more atrophied. The disease is seen most frequently in persons having a thick, coarse, dark-colored skin.

Pathology.—Keratosis pilaris is essentially characterized by a hypergenesis of the epidermic cells in the hair follicle. The cells of the Malpighian layer in the

Fig. 3583.—Keratosis Pilaris. Showing funnel-shaped plug distending follicle. It is continuous on either side with the hypertrophied horny layer and rises above surrounding level. (Courtesy of Dr. John A. Fordyce.)

hair follicle are found to undergo rapid cornification and to be arranged loosely around the hair shaft, so as to form a plug which projects above the surface. (Fig. 3583.) The hair shafts, when included, are often twisted and deformed and the papillæ of the root are reduced in size, or entirely wanting. Patches of necrosis are found here and there at the point of insertion of the arrectores pilorum. On the other hand, actual infiltration may occur, usually affecting the superficial rather than the deeper portions of the follicles. Giovanni found in many cases that the sebaceous glands were entirely wanting, while, in the others they were reduced in size. As a rule, the sweat glands are unaffected.

Diagnosis.—Keratosis pilaris differs from gooseflesh (cutis anserina) in its permanency and in the fact that it is uninfluenced by temperature. Pityriasis pilaris rubra is the only dermatosis which is likely to simulate the affection. However, there is this difference, pityriasis pilaris rubra is characterized by peripolar and squamous prominences, exhibiting a peculiarly dark and smirched appearance, on the back of the fingers; by the affection of the nails; and, finally, by palmar and plantar desquamation. Keratosis pilaris is distinguished from the papular syphilides by its persistently unchanging character and the absence of specific concomitants.

Prognosis.—The general health is in no wise affected by the disease, even when most pronounced. The disease is curable, but, without proper treatment, may last indefinitely.

Treatment.—Frequent baths with the use of a proper toilet soap, or, better still, sapo viridis, will usually be found curative. Alkaline, Turkish, and vapor baths will also be useful, although, in very obstinate cases, Brocq considers that the surest treatment is the destruction of the hair follicles by electrolysis. Grover W. Wende.

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Kerion.—See *Tineas.*

Ketoses.—As an example of a ketose may be cited the monosaccharide sugar levulose. Levulose is a ketone derivative of a polyhydric alcohol and inasmuch as all carbohydrates are characterized by the suffix "ose" all ketone carbohydrates are designated as ketoses. See also *Aliment.* F. P. U.

Key, Ernst Axel Henrik.—A distinguished Swedish medical authority and hygienist of the nineteenth century. Born in Smaland, Sweden, in 1832. He received his doctor's degree in 1862, and during the

Fig. 3584.—Ernst Axel Henrik Key.

same year was chosen Professor of Pathological Anatomy in the Caroline Medical Institute of Stockholm. In 1886 he became Rector of this school, and he retained this office up to the year 1897, when he resigned his professorship and accepted a pension from the State. He died in 1901.

Only a few of Key's writings bear German titles, the remainder having been published in Swedish. The few referred to are the following: "Experimentelle Untersuchungen über die Entzündung der Hornhaut," written in association with C. Wallis

and published in *Virchow's Archiv*, 1872; "Schulhygienische Untersuchungen," 1889; and "Die Pubertätsentwickelung und das Verhältniss derselben zu den Krankheitserscheinungen der Schuljugend," Berlin, 1890. A. H. B.

Key West.—See *Florida*.

Kidneys, Amyloid Disease of the.—*Synonym:* Lardaceous or waxy kidney.

History.—The names of Rokitansky, Meckel, and Virchow are intimately associated with the early history of this degeneration. In 1842, Rokitansky described the gross pathology of the lardaceous kidney, and spoke of it as a separate form of Bright's disease. Before this time it was considered a simple form of Bright's. Later Meckel emphasized its various etiological factors. He established the iodine and sulphuric acid reaction, but thought that the substance was identical with cholesterin. Virchow pointed out the errors in Meckel's demonstration. He believed that this substance belonged to the cellulose group, because of its reactions with iodine, and gave to it the name of amyloid, which has clung to it ever since, notwithstanding the fact that it has since been shown that the substance is a glycoprotein containing chondroitin-sulphuric acid and therefore allied to the chondrin of cartilage.

Etiology.—Age and sex seem to have little or no influence in the production of this condition. It was early recognized that this degeneration was found in connection with the cachectic state which occurs secondary to chronic suppuration and that, as a rule, it was general, involving the liver, spleen, and kidneys. The influence of syphilis and tuberculosis in themselves is probably slight since it apparently does not appear in these diseases unless secondary infection has occurred and chronic suppuration has developed. Empyema, chronic osteomyelitis (pyogenic and tuberculous), pyelitis, psoas abscess, and chronic pulmonary tuberculosis with cavity formation are the forms of suppuration with which amyloid kidney is most frequently associated. Rarely cases have been found accompanying carcinoma. Experimentally amyloid has been produced by some of the pus germs (Krakow). It is not infrequently associated with chronic inflammatory and fibrotic changes in the kidney.

Morbid Anatomy.—The gross appearance of the kidney depends upon the extent of the degeneration and the variety of the associated nephritis. It is large, firm, and heavy unless associated with chronic indurative fibrosis when it may be small and granular and look like that of a chronic interstitial nephritis. The surface is pale and smooth and the stellate veins are prominent. The capsule strips readily unless there is much fibrosis. The cut section shows a smooth glistening surface with a clear differentiation between the deep red pyramids and the wide, light yellow, waxy-looking cortex. The glomeruli show distinctly, standing out like dew drops. If the cut surface is washed free of blood and then flooded with tincture of iodine or Lugol's solution, the amyloid material strikes a mahogany red which turns black on the addition of sulphuric acid. If the process is advanced this may be made out with the naked eye but it is beautifully shown in microscopic sections. On microscopic examination the change is seen to be limited to the blood-vessels, to the muscular coat of the arteries. The vessels in the glomeruli are first affected and may be entirely converted into amyloid, or the process may be a patchy one. The rest of the kidney is seldom normal, often presenting the changes seen in nephritis. Cardiac hypertrophy and arteriosclerosis probably are never the result of amyloid kidney but may be associated with it. The renal epithelium is not affected.

Symptoms and Signs.—There are no pathognomonic signs of this condition. The presence of albumin in the urine, and of edema and diarrhea, is very suggestive, especially if combined with the presence or the history of prolonged suppuration. These patients are usually pale, emaciated and cachectic. The detection of an enlarged liver or spleen not otherwise explained is extremely suggestive. Diarrhea is a frequent and important symptom and in some instances is due to the involvement of the intestine in the lardaceous process. If persistent it has much to do with the fatal issue. Edema may be very marked but is frequently absent. The variety of the nephritis associated with the amyloid change must of necessity alter the signs. Apoplexy and albuminuric retinitis are said to be uncommon.

The urine shows important changes but none of them are pathognomonic. The volume is usually increased. It is pale, of low specific gravity and often rich in albumin and globulin. Hyaline, granular and fatty casts may be found. It should be noted that the so-called waxy or amyloid cast has nothing to do with amyloid degeneration of the kidney. Blood is a rare finding.

The duration of the disease is extremely variable and is controlled largely by the character of the causative and associated conditions. Death occurs from exhaustion or as a result of complications. Uremia is rare.

Treatment.—The treatment is practically exclusively that of the causative disease. Fresh air, sunshine and an abundance of good nourishing food are important factors. Tonics of iron or arsenic or both are indicated for the relief of the anemia. Prophylaxis is, of course, very important. Syphilis should be treated if present and all suppurating foci cleaned and healed as soon as possible. The advance in the treatment of these conditions which has been made during the past ten years is believed greatly to have reduced the incidence of amyloid disease.

James Rae Arneill.
Revised by Ralph G. Stillman.

Kidneys, Anatomy and Physiology of.—I. Anatomy.—The kidneys are bean-shaped dark brownish-red organs situated on either side of the spinal column. They are usually said to lie in the lumbar region but are really intersected by the horizontal and vertical planes which separate the hypochondriac, lumbar, epigastric, and umbilical regions from each other and may therefore be said to lie in all these segments of the abdominal space. They lie on the fascia of the M. quadratus lumborum and on the vertebral portion of the diaphragm and extend from the first or the third lumbar vertebra to the eleventh rib or even higher. The left kidney is usually somewhat higher than the right.

The kidney presents two surfaces, two borders, and two extremities. The surfaces are ventral and dorsal, the ventral surface being more convex than the dorsal. The external border is convex, while the internal border is fissured by the hilum. The upper extremity is usually larger than the lower and is usually somewhat nearer to the median line.

The kidneys are usually of a flattened oval shape with the long diameter nearly parallel to the vertebral column. The form is, however, very variable. The kidneys may be slender, the length being three times the breadth and the convex and concave borders almost concentrically curved, or they may be short and broad, the vertical diameter being only a little greater than the transverse. More rarely the kidney may appear as an almost elliptical disc. In this case the place of entrance of the vessels is crowded toward the posterior surface. The sagittal diameter (thickness) is generally in inverse ratio to the transverse.

The left kidney is usually higher, narrower, and thicker than the right. The vertical diameter of the kidney averages 12 centimeters, the transverse 6 centimeters, and the sagittal 3.5 centimeters. The volume is from 100 to 175 c.c., averaging 135 c.c. (Krause). The weight of a normal kidney varies between 90 and 180 grams, the left being 5 to 7 grams heavier than the right. The kidneys of males are ordinarily heavier than those of females. The weight of the two kidneys is to the weight of the body as 1 to 240.

The hilus renalis is a longitudinal cleft with anterior and posterior lips, the posterior usually projecting nearer to the median line than the anterior. Between the two lips pass the renal vessels and nerves, the duct, and a quantity of fat-bearing connective tissue. The sinus renalis is flattened in the sagittal diameter, bounded by an anterior and a posterior wall, having circular or elliptical sharp borders. It extends mesially to the hilus and repeats the external contour of the kidney. The sinus contains a mass of adipose tissue in which are embedded the branches of the blood-vessels and excretory duct. It gives attachment to the primary branches (calices) of the duct.

The kidneys are placed behind the peritoneum and are surrounded by a loose tissue generally filled with fat and constituting the fatty capsule. The adipose tissue is especially well developed around the margins of the kidney and in it the renal vessels and nerves lie before they enter the kidney. As they enter they are surrounded by this loose fatty tissue which fills up the space in the renal sinus not occupied by vessels and nerves. A layer of fibrous tissue known as renal fascia surrounds the kidney, the anterior wall being attached to the peritoneum while the posterior merges in the loose cellular retroperitoneal tissue. The anterior and posterior walls are fused above and external to the kidney but remain separate below and on the median side; the anterior wall joins the anterior wall of the opposite side. The perirenal fat is sometimes divided into pararenal—outside the renal fascia—and perirenal—within that fascia. The kidney is not held in place by any definite attachments, but only by pressure of surrounding organs and by the renal fascia. Loosening of these connections is not infrequent and brings about the condition known as movable or floating kidney. In rare cases, the kidney may be surrounded by peritoneum and held in place by a mesonephron.

The lower edge of the left kidney is usually nearly five centimeters from the iliac crest, a little below the level of the second lumbar spine; that of the right is generally from 1.25 to 2 centimeters lower. The right kidney is covered in front by the descending duodenum and flexura coli dextra, while the liver with its *impressio renalis* often covers a considerable portion of the upper part. In front of the left kidney is a part of the posterior portion of the stomach, and the *flexura coli sinistra*. The external margin of the left kidney is partially covered by the spleen. The adrenals cover the upper extremities of both kidneys, projecting a little over the anterior surface and mesial border.

The kidney is surrounded by three sheaths, an outer fatty sheath, a middle fibrous sheath and an inner muscular layer. The outer sheath, or *capsula adiposa*, consists of loose connective tissue, containing an amount of fat which varies withthe nutritive conditions of the body. It is loosely connected to the middle sheath, which consists of a thin but firm layer of fibrous tissue, which can be easily peeled off from the healthy kidney, leaving a smooth surface and causing but little hemorrhage when undertaken during a renal operation. This capsule consists of two layers which are easily separated, the outer 0.1 to 0.2 millimeter in thickness which fuses in the sinus renalis with the connective-tissue sheaths of the blood-vessels. The inner and thinner layer continues to the point of attachment of the calices. Under this inner layer is a thin layer of smooth muscle fibers, which form a network, whose meshes are about equal in size to the diameter of the larger superficial veins. From this plexus fine processes enter the substance of the kidney.

After the removal of the capsules, the outer surface of the kidney usually appears smooth, reddish-brown in color, and of firm consistency. The color and consistency, however, vary with the blood content. Exceptionally the outer surface is traversed by shallow furrows, the remains of the lobulation of the fetal kidney, which is distinctly marked in the kidneys of the new-born infant. The inner surface bordering on the sinus renalis is also smooth in the neighborhood of the entrance of the sinus, but presents some transverse furrows on the anterior lip, the impressions of the arteria renalis. The hilum is merely an orifice opening into the cavity of the sinus renalis. This sinus is from ten to twelve millimeters in diameter and from thirty to thirty-five millimeters deep. In the deeper portion of the sinus the surface is uneven, presenting low, pyramidal projections with flat or rounded summits. These are the papillæ renales, of which there are from four to thirteen, generally seven or eight quite uniformly distributed over the anterior and posterior walls. The papillæ may be simple, or several may be fused into a single papilla having a larger base and furrowed sides. The simple papillæ are about eight millimeters in height, the bases having a diameter of six to ten millimeters. Near the base of each papilla is fused the circular edge of an end branch of the ureter, a so-called renal calyx, so that the papilla forms the base of the calyx, its apex projecting into it. The rounded summit of each papilla is pierced by numerous small openings or foramina, the mouths of the collecting ducts of the renal tubules. These foramina form the area cribrosa. Numerous blood-vessels penetrate the inner surface of the kidney above the neck of the papillæ and thus outside of the calices; these are often arranged concentrically about the base of the papilla.

On section of the kidney through the hilum, the parenchyma is seen to be composed of two essentially different structures, the medulla and the cortex. The medulla consists of a variable number (eight to eighteen) of conical segments called renal pyramids or pyramids of Malpighi, the apices of which project into the sinus and are surrounded by the calices, while the bases of the pyramids are turned toward the surface of the kidney and are surrounded by the cortex. The apices of the pyramids form the papillæ noted in the floor of the sinus. Two or three, however, enter into the formation of each papilla in the central portion of the kidney and six or more toward the superior and inferior ends of the organ. The pyramids are smooth and glistening and present, even to the unaided eye, a longitudinal striation, indicating the course of the collecting tubules. The apex or papilla when viewed with a low-power lens presents numerous apertures, the foramina papillaria, through which the secretion escapes into the duct. The cortex may be divided into two portions: a peripheral layer, the cortex proper, five to seven millimeters in thickness, which extends over the entire surface of the kidney between the bases of the Malpighian pyramids and the fibrous capsule, and an interpapillary portion, the renal columns, or columnæ Bertini, dipping down between the Malpighian pyramids to the bottom of the sinus, where they are covered by the fibrous capsule and more or less adipose tissue. The cortical substance is granular, grayish in color, varying however with the blood content, and characterized especially by the occurrence at quite regular intervals of red points visible with the unaided eye; these are the so-called glomeruli, consisting of coils of fine capillaries. At quite regular intervals processes extend from the bases of the Malpighian pyramids toward the outer surface of the kidney. These have the color and the striated

appearance of the medullary substance and are known as pyramidal processes or medullary rays, or pyramids of Ferrein or pars radiata of the cortex. The part of the cortex between these rays is called the pars convoluta. Pyramidal processes also extend from one pyramid to another through the cortical substance which separates the pyramids.

The calices open into the expanded pelvis of the kidney, which is continuous with the ureter, the excretory duct of the kidney.

Various anomalies of form and structure of the kidneys have been described. The form of the kidneys, as previously stated, may be markedly different from the typical form described. They may be

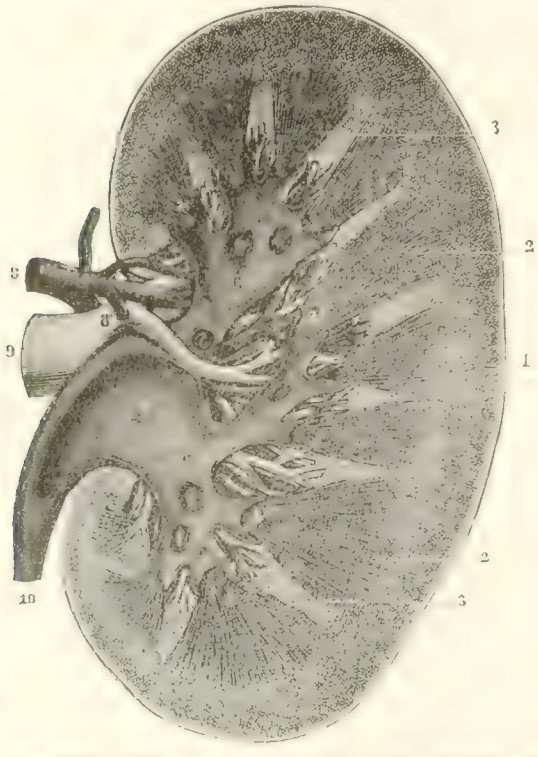

Fig. 3585.—Median Section of the Right Kidney Showing the Renal Pelvis, Papillæ, Calices, with Blood-vessels and Ureter; also the general Structure of the Kidney. 1, Cortical substance; 2, pyramids of Malpighi, with two papillæ; 3, columns of Bertini; 4, pelvis; 5, calyx; 6, papillæ situated in a plane anterior to that of the section; 7, section of a calyx receiving the papilla of a pyramid in the segment posterior to the section; 8, renal artery with 8′ its posterior branch; 9, renal vein; 10, ureter. (Testut.)

unequal in size, one being small while the other is compensatingly large. One kidney may be lacking, the other occupying the normal position on one or the other side. As a very rare anomaly, the occurrence of three kidneys has been reported. In this case, the supernumerary kidney is either lateral or median. Numerous cases have been reported in which the ureter on one or the other side was double. In some cases the two ureters were separate throughout their entire length, opening separately into the bladder, while in other cases the two fused after an independent course varying in length. The position of one or both of the kidneys may be changed; they may encroach upon the iliac fossa, or even enter the pelvis in front of or behind the rectum; or the organ may lie upon the vertebral column or even cross to the opposite loin. The two kidneys may be fused; if only the lower extremities are fused, this phenomenon results in the formation of the horseshoe-shaped kidney, which is usually median in position. In other cases the mass consisting of the fused kidneys is on one or the other side and varies in shape. In the case described by McMurrich, the fused mass occupied the left side, the left kidney being fairly normal in shape, while the right was discoidal in shape and had crossed over and fused with the anterior surface of the left. A ureter arose from each portion of the mass passing downward and opening into the bladder in the normal position. While the anterior surface showed the line of demarcation between the two kidneys, the posterior surface was smooth and showed no indication of a separation. Only twenty-eight similar cases have been recorded. The variations in motility, with the phenomena of palpable and movable kidney, have already been mentioned.

On microscopic examination the kidney is seen to be composed of numerous twisted and convoluted tubules known as the uriniferous tubules. Each tubule begins in the cortex of the kidney between the medullary rays in an enlarged, expanded, cup-shaped portion known as the capsula glomeruli or glomerular capsule or the capsule of Bowman, which surrounds the glomerulus, the two together bearing the name of the renal or Malpighian corpuscle. The glomerulus consists of a complicated loop of capillary blood-vessels, covered by a reflection of the delicate wall of the capsule. These corpuscles may be seen as minute red points just visible to the unaided eye. The capsula glomeruli opens through a narrow neck into a larger convoluted portion, called the first or convoluted tubule. After describing many tortuous windings, it passes from the convoluted part into a radiate part as the less complicated spiral tubule. It then enters the base of the pyramid as a straight, slender tubule, which descends a variable distance into the medullary substance, then turns sharply, describing a loop and returns into the cortex in a larger straight tubule running parallel to the descending limb of the loop. The small descending limb, the loop, and the larger ascending limb have collectively received the name of the loop of Henle. Leaving the radiate part, the tubule then re-enters the pars convoluta as the irregular tubule, which, becoming more uniform in appearance, receives the name of second or distal convoluted tubule, which passes, as shown by Huber and by Stoerk, close to the glomerulus in which the individual tubule originated. The second convoluted tubule ends in a short junctional tubule which passes back into a radiate part and joins a collecting tubule. Each collecting tubule receives many kidney tubules and descends in a straight course through the radiate part of the cortex and through the pyramid of the medulla. The capsules, the neck, the first and second convoluted portions of the uriniferous tubules and the functional tubules are found in the cortex between the medullary rays. The medullary rays are formed by the cortical portions of the collecting tubules and a portion of the ascending limbs of the loops of Henle. The medulla is made up mainly of straight collecting tubules of various sizes and of the descending limbs and loops of Henle's loops, the latter being often found in the boundary zone between cortex and medulla. The different portions of the tubules vary markedly in size, the renal corpuscle measuring 120 to 220μ in diameter, the first convoluted tubule from 40 to 70μ in diameter, while the loops of Henle present tubules having a diameter of 9 to 15μ in the descending limb and 23 to 28μ in the ascending limb. The distal convoluted portion is from 39 to 45μ in diameter, while the collecting tubules vary from 45 to 75μ in diameter. The large collecting tubes unite in the medullary pyramids to form about twenty papillary ducts from 200 to 300μ in diameter which empty into the pelvis of the kidney through the foramina papillaria.

The character of the epithelium lining the uriniferous tubules in the different portions varies markedly and has been subjected to most careful histo-

logical investigation. The epithelium of the capsula glomeruli, which forms a double-walled membrane around the glomerulus, leaving a cleft-like space which forms the beginning of the uriniferous tubule and communicates with the lumen of the proximal convoluted tubule, is simple squamous in type. The glomerular epithelium is very flat, with nuclei projecting slightly into the lumen, while that lining the outer wall of the capsule is somewhat higher, but still distinctly squamous in type. The flattened epithelium of the capsule changes gradually into cubical epithelium of the neck and that into short and rather irregular columnar epithelium of the convoluted tubules. These cells show a basal striation and often a cuticular border, and, as the investigations of Nussbaum and Heidenhain seemed to show that they were especially concerned in the process of secretion in the kidney, they have been subjected to most searching study, with the view of determining the structure of the cells and the changes of structure during the process of secretion. Henle showed that the epithelium of this portion of the uriniferous tubule is characterized by a dark, granular appearance of the protoplasm, while Krause mentions the basal striation of these cells. A zone of short stiff cilia was demonstrated in certain renal cells of amphibia and fishes by Nussbaum, the observation being extended to mammalia, including man, by Cornil, Tornier, Klein, and others. This zone is characterized by Tornier as the *Bürstensaum*. Since this zone was not always found and when present was always connected with a certain thickness of epithelium found in different kidneys and different areas of the same kidney, the conclusion was drawn that the cells undergo uniform histological changes during the processes of secretion. Van der Stricht says that the resting cell presents a homogeneous cuticular zone, below which is a close-meshed protoplasmic network, which shows a parallel arrangement of its fibrils in the peripheral portion of the cell, producing the "rod structure" of Heidenhain. When the secretion begins, clear droplets of secretion form, especially in the neighborhood of the nucleus, which press toward the free surface, fill the formerly homogeneous cuticular zone and break it up into the "Bürstensaum." In a later work, Van der Stricht describes four types of cells in the convoluted tubules: (1) Cells like those above described, which he regards as resting cells; (2) cells with the Bürstensaum, in the protoplasmic network of which the secretion is in the form of fine droplets, especially toward the lumen; (3) cells without a cuticular border also filled with the secretion; (4) granular cells with distinct rod structure in the peripheral portion of the cell, while the central portion is changed into a clear mass filled with granules. Such cells are also found in the ascending limb of Henle's loop together with cells which have a distinct cuticular border. Van der Stricht also describes in the glomerular epithelium during the process of secretion the collection of clear droplets with processes in the protoplasm of the cells. Disse, working on fresh, well-fixed human tissue, distinguished four forms of tubules: (1) Tubules with wide lumen and low, quite uniformly granular epithelial cells in which cell contour and rod structure cannot be distinguished. The free surface shows the Bürstensaum distinctly developed, formed of stiff hairs provided with nodular thickenings at their bases. (2) Tubules with narrow cylindrical lumen and spherical epithelium. The protoplasm is still generally uniform, but in some cells clearer parts begin to be seen giving the cell a spotted appearance. The Bürstensaum is wanting. (3) Tubules with narrow, irregularly star-shaped lumen and tall cells. In these, two portions are distinguished, a central clear part containing the nucleus, and a darker basal portion in which rows of fine granules begin to produce the picture of the "rod structure." No Bürstensaum is seen in these cells. (4) Tubules entirely filled by the tall epithelial cells, which show a distinct differentiation of the central and basal portions. The nucleus in the central portion of the cell is very bright and clear and resembles a vesicle filled with clear fluid. Rod structure is very distinct in the basal portion of these cells, but no Bürstensaum is to be seen. Sauer, however, states that the secretory portions of the uriniferous tubules have the same type of epithelium, while the lumina naturally are subject to great variation. The striation of Heidenhain and the peculiar terminations of Tornier were found by him in all phases of secretion, being finer or coarser according to the height of the cells. Hence he concludes that these peculiarities of structure have nothing to do with the processes of secretion, but are permanent structural appearances. Rothstein describes an irregular branching and interlocking of the processes of the cells of the convoluted tubules in the dog and rabbit, giving to these cells a peculiar frayed-out appearance similar to that described for these cells in the guinea-pig as mentioned in the text-book of Böhm, Davidoff, and Huber. Landauer investigated these cells in many species of vertebrates and also in man and concluded that the convoluted tubules and the ascending limb of Henle's loop are lined by cells which are sharply outlined and provided with longitudinal folds, which interlock, and it is these folds that give these cells the striated appearance (rod structure of the authors). Zimmermann describes in detail the epithelium lining the different portions of the uriniferous tubules, especially emphasizing the presence and relations of the "Centralkörper or Centralgeissel" in these cells. He also distinguishes the darker cells showing striation and brush-like border and cells which are large and clear, the structure of which is quite indistinct. Benda in 1903 published a method of fixing small bits of kidney tissue in Fleming's mixture and staining with crystal violet to bring out and stain especially and specifically certain structures in the cells which he calls mitochondria. These are generally regarded as identical with the rods forming Heidenhain's basal striation. Benda ascribes a motor function to these filaments and thinks that by their contraction the vacuoles of secretion are forced out of the cell through the striated border. Meves in 1906 observed variations in them which Policard ascribes to functional variations. Meves distinguishes chondriomites, granular filaments, and chondriocontes, non-granular filaments. Policard describes three types of filaments, (1) continuous, (2) consisting of a chain of four to eight rods and appearing like streptobacilli and (3) granuliform, having the appearance of streptococci. Kolster also finds chondriomites, chondriocontes and chondriosomes. He thinks that on diuretic stimulation the rods change to granules and then to secretion. Retzius emphasizes the fact that the fibrils do not anastomose and form a network, though some do branch dichotomously and regards them as a beautiful example of Fleming's mitom, but with a specific direction arrangement. They begin at the basal membrane and pass toward the lumen; in cells with distinct brush border, the fibrils extend to the outer edge of this border and end there in a granule which stains intensely in hematoxylin. The filaments, Retzius states may reach the inner border of those cells which are filled with secretion.

The Bürstensaum or brush border has also been recently investigated. Retzius states that it really consists of short, narrow straight rods and finds true ciliated cells in the frog's kidney, at the neck and continuing some distance into the convoluted tubules. Policard, on the other hand, thinks that it is not composed of rods or cilia embedded in cement, but is a continuous membrane, extending over the cells and so traversed by fluids as to give the effect of a striation.

The intercellular boundaries are generally recognized as ill-defined, but Retzius has been able to demonstrate them by means of silver stains in spite of the

fact that the intracellular filaments of adjoining cells intermingle.

The cells of the convoluted tubules are then generally recognized to have a rodded basal structure, due to generally parallel arrangement of the granular or rodded filaments, whose function is not yet incontestably decided, but which are believed to have something to do with the process of secretion. The structure of the striated brush border and its relation to secretion are still less decisively known. The variations observed in it are ascribed by some to faulty fixation and by others to secretion changes.

The nucleus seems not to suffer any changes of structure during secretion, although changes of position have been observed. It ascends toward the free

Fig. 3586.—Epithelium of Kidney. 1, Collecting tube viewed in longitudinal section; 2, transverse section of collecting tube; 3, ascending limb of Henle's loop; 4, descending or narrow limb of Henle's loop; 5, longitudinal section of descending limb; 6, convoluted tube.

surface of the cell with the secretion, returning toward the basal surface of the resting cell. Disse concludes that, as signs of proliferation are never seen in these cells in the adult the cells do not degenerate after secretion. Zimmermann describes fine densely placed fibers staining black in the iron hematoxylin, which run circularly around the tubuli contorti between the bases of the cells and the basement membrane. He was unable to decide, however, whether these were special kinds of fibers or cell processes or basal lines of cement substance. The descending limb of Henle's loop is lined by flattened cells, with nuclei projecting slightly into the lumen, the nuclear projections of the two sides alternating, thus giving to the section a wavy appearance. The cells of the loop and of the ascending limb are higher and approach the columnar type of the convoluted tubules. In the second convoluted tubule, the epithelium closely resembles that in the

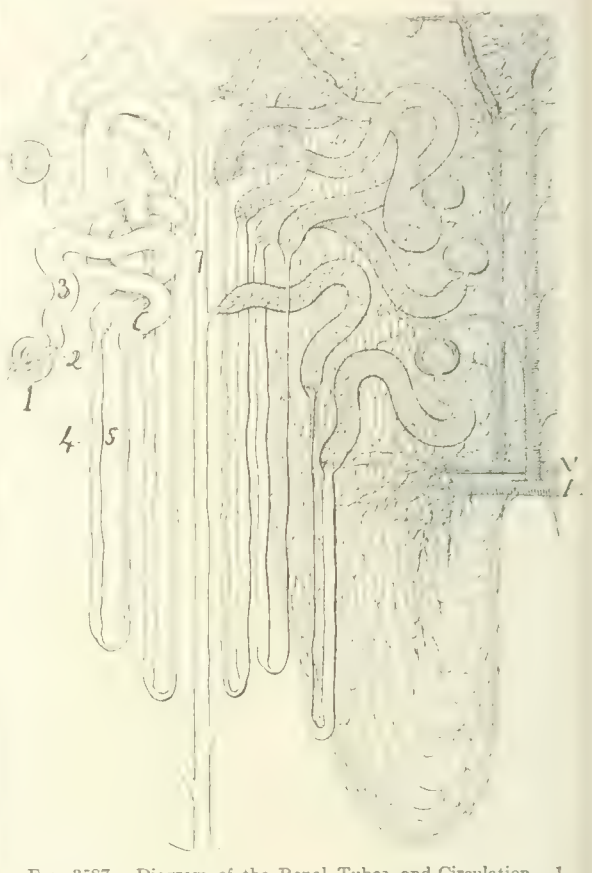

Fig. 3587.—Diagram of the Renal Tubes and Circulation. 1, Malpighian body; 2, neck; 3, proximal convoluted tube; 4, descending limb of Henle's loop; 5, ascending limb; 6, distal convoluted tube; 7, collecting tube; *A*, artery; *V*, vein. An intralobular artery is shown ascending and giving off branches to the tufts; the straight arteries descend; the intralobular vein is shown commencing as a stellate plexus on the surface.

first convoluted tubule, while the lining of the junctional tubule is cubical in type. The epithelium of the straight collecting tubules is low columnar at first, increasing in height as the tubules increase in size. Although a granular structure is usually limited to the cells of the convoluted tubules, Benda demonstrated mitochondria, not only in the first convoluted tubule, but also to a less extent in the cells of the ascending limb of Henle's loop, in the second convoluted tubule in the junctional tubule and even in the beginning portion of the straight tubules of the medullary rays.

By biochemical methods, Macallum has found iron and phosphorus in the cells of the convoluted tubules and Justus has found iodine, while Lillie, as a result of investigations with paradiamido benzene and α-naphthol has shown that in the frog's kidney the surface of the nucleus has strong oxidizing properties. The pelvis of the kidney, as well as the ureter,

is lined by a stratified transitional epithelium, like that in the bladder.

Under the epithelium of the uriniferous tubule throughout its entire extent is a basement membrane, the character and structure of which have been investigated by Rühle, Disse, von Ebner, Mall, and others. Mall's investigations were carried on largely by pancreatic digestion and subsequent staining in acid fuchsin and picric acid. As a result of this work, the framework of the kidney was shown to consist of white fibrous connective tissue and reticulum, Mall and Rühle describing "baskets" of reticular fibrils as surrounding the tubules and forming the basement membranes. Disse and von Ebner, however, refer the fibrillar appearance to the methods of preparation, and Mall, in his latest work on these membranes, demonstrates clearly within the "basket" of connective-tissue fibrils previously described, a homogeneous membrane which was destroyed by pancreatic digestion and which is chemically different from the reticular tissue and also from both white fibrous and yellow elastic connective tissue.

Between the tubules is found a small amount of connective tissue, which is more abundant around the

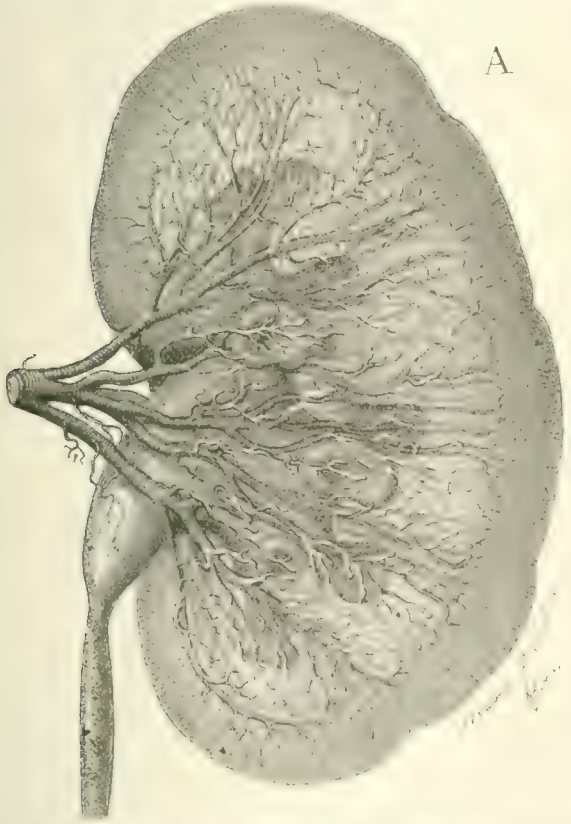

FIG. 3588.—The Renal Artery and the Distribution of its Branches with Relation to the Pelvis. (Broedel, Johns Hopkins Hospital Bulletin.)

blood-vessels and Malpighian corpuscles, near the junction of cortex and medulla and between the collecting tubules in the apices of the Malpighian pyramids.

Blood Supply of the Kidney.—The kidney receives a very rich blood supply, and the arrangement and distribution of its blood-vessels are of the utmost importance both from a physiological and from a surgical point of view. The main arterial supply is from the renal artery, a branch of the abdominal aorta. Collateral branches, however, reach the surface of the kidney through the capsule, arising from the suprarenal, spermatic, lumbar, and other arteries.

The intrinsic blood-vessels of the kidney have been investigated by Broedel and by Keiller to determine the relation of the branches in the pelvis and kidney, with especial reference to their significance in nephrectomy. Although working independently and by quite different methods, the two last-named writers arrived at nearly the same results and at nearly the same time. Broedel used, in his investigation, the Schiefferdecker corrosion method, combined with injection of the arteries, of the veins and pelvis, and finally triple injection of arteries, veins, and pelvis. He divides the renal pelves into true pelves, in which all the calices, major and minor, open into a common pelvis, and divided pelves, in which there is no free communication between all the calices of the kidney. He states: "The renal artery divides at the hilum, as a rule, into four or five branches, the distribution of which, in relation to the pelvis, is such that three-fourths of the blood supply is carried anteriorly, while one-fourth runs posteriorly. The relative size of the two systems may occasionally be $\frac{4}{5}:\frac{1}{5}$, $\frac{2}{3}:\frac{1}{3}$, but rarely $\frac{1}{2}:\frac{1}{2}$. The arteries are end arteries in the strictest sense of the word and the branches of the anterior division never cross over to the posterior side and *vice versa*. They do not anastomose with each other.

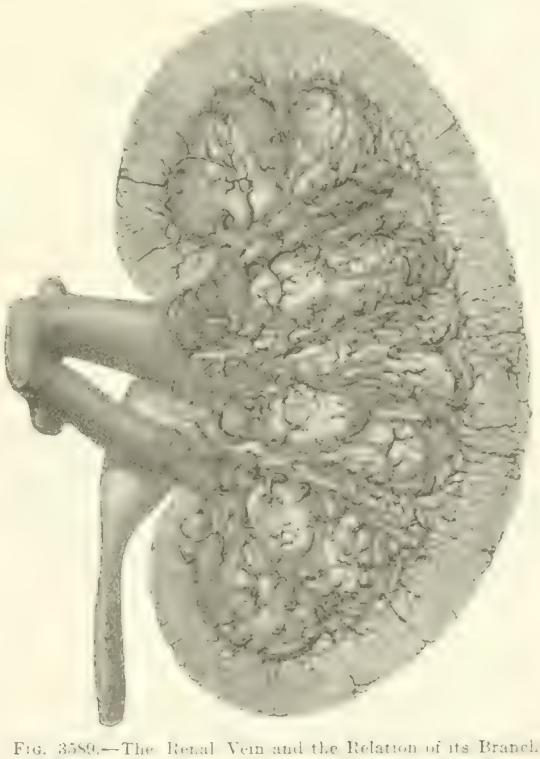

FIG. 3589.—The Renal Vein and the Relation of its Branches to the Pelvis of the Kidney. (Broedel, Johns Hopkins Hospital Bulletin.)

To Hyrtl apparently is due the credit of having first mentioned this 'natürliche Theilbarkeit der Niere,' by which he means that in a corrosion specimen, the two arterial systems are completely separated by the pelvis. He also affirms that this arrangement of the renal arteries is found 'without exception in all mammalia from the whale to man.'"

The surgical significance of this work of Broedel's is seen in the possibility of an incision through the renal substance in the plane separating the areas supplied by these two independent systems. Concerning the

veins, Broedel states: "While there is a complete arterial division in the plane connecting the posterior calices and terminating in the lateral half of the upper and lower calices, the veins follow quite a different arrangement. Around the bases of the pyramids they anastomose and form the familiar venous arches. They unite in large branches that run between the sides of the pyramids and the columns of Bertini to the necks of the calices, where they lie between the

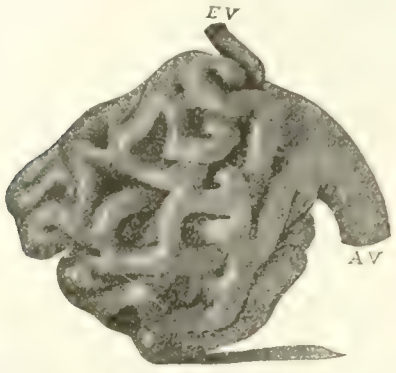

Fig. 3590.—Wax Model of Glomerulus of Human Kidney. Enlarged 444 diameters, seen in profile from the left side. *AV*, Afferent vessel; *EV*, efferent vessel. (Johnston.)

pyramid and the arterial branches. The thickness of these collecting veins accounts for the peculiar lobulated appearance of the bases and sides of the pyramids. Around the necks of the calices, both anteriorly and posteriorly, these veins form a second system of anastomoses, much shorter and thicker than that at the base of the pyramids. This appears as a number of thick loops or rings which fit like a collar around the necks of the calices. Nearly all the collected blood of the posterior region is carried anteriorly through these short thick stems, to join that of the anterior portion."

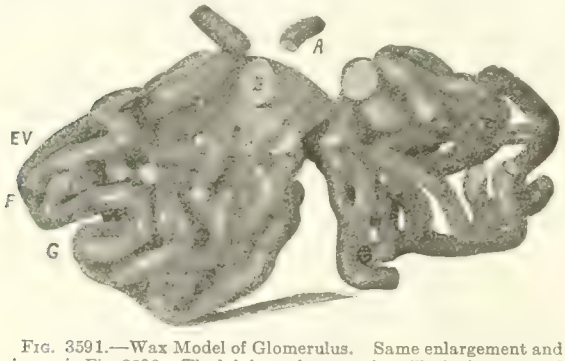

Fig. 3591.—Wax Model of Glomerulus. Same enlargement and view as in Fig. 3590. The left lateral group of capillaries is separated from the median group and turned back, exposing the interior of the glomerulus, *A*. A short section of a capillary of the median group is removed to show the course of the deeper lying capillaries. (Johnston.)

Huber has investigated the arrangement of the arteries within the kidney by means of celluloid alkanin injections followed by corrosion with strong hydrochloric acid. By this method, he was able to follow the branchings and terminations of the arterial trunks within the kidney very perfectly and his account may here be followed. His observations were made on the dog, cat, rabbit, guinea-pig, and rat. The renal artery, on entering the hilus of the kidney, divides into branches, which after division course in the peripheral part of the medullary pyramid, maintaining a direction in the main parallel to the surface of the kidney; they therefore describe arcs with convexity outward (the arcuate arteries). At intervals of two to five millimeters, branches are given off from the convex side of the arches at an acute angle to the arch and passing toward the cortex. From the outer side of these branches, short branches are given off which pass toward the periphery, generally subdividing several times before the so-called interlobular arteries arise. The interlobular arteries branch at various levels, giving rise to afferent glomerular branches which enter the glomerulus and divide into several branches which redivide and break up into a network

Fig. 3592.—Diagram of a Malpighian Body Showing the Afferent and Efferent Vessels above, with the Tuft. The reflection of the cells of Bowman's capsule over the vessels is shown on the left: on the right, the cells are shown in the flat; the neck and part of a convoluted tube are shown below. The space between the tuft and the capsule is drawn wider than normal.

of anastomosing capillaries as described by Johnston. This arrangement is shown diagrammatically in Fig. 3592 and more exactly in Figs. 3590 and 3591 representing Johnston's models of the human glomerulus. He describes a network of reticular tissue arising from the membranes surrounding the glomerulus and forming the framework of the glomerulus in the meshes of which are found the capillaries and fine branches of the afferent artery. The blood collects into small branches which unite to form the efferent artery; this runs for a variable distance and finally breaks up into a second system of capillaries around the convoluted tubules. Afferent glomerular branches therefore arise from the arcuate arteries and all their

branches. Arteries to the sinus and pelvis arise generally from primary branches of the renal artery. The number and arrangement of afferent glomerular arteries is quite irregular. Each glomerulus constitutes a rete mirabile, its efferent branch being regarded as still an artery, not a vein. The efferent glomerular arteries divide into a second system of capillaries, the distribution of which varies according to the location of the glomerulus. The vasa efferentia from glomeruli in the outer parts of the kidney send capillaries to the convoluted tubules. The vasa efferentia from glomeruli in the deeper parts of the kidney, whether their afferent arteries were derived from the arcuate artery or its successive branches or from the lower interlobular arteries divide into bundles of long slender branches and capillaries which pass into the medulla of the kidney as the so-called arteriolæ rectæ, supplying the straight tubules of the medulla. This account differs from the description usually accepted up to the time of its publication in that all the kidney tubules of both cortex and medulla are supplied by capillaries which have already passed through a glomerular capillary plexus, while the older version was that the tubules of the medulla were supplied by special branches from the arcuate arteries. It confirms, however, a statement made by Bowman in 1842 that all the blood of the renal artery except a small portion to the capsule, surrounding fat and coats of larger vessels, enters the tufts of the Malpighian bodies and thence passes out into the capillary plexus surrounding the uriniferous tubules. This point is of importance from a physiologic point of view.

Huber has also investigated by means of corrosion preparations the veins of the kidneys of the rabbit, guinea-pig, rat, cat, and dog. In the rabbit, guinea-pig, and rat, he finds the veins beginning in the renal

Fig. 3593.—Corrosion Specimen of the Terminal Arterial Branches of the Kidney of a Rabbit. (Huber, Am. Jour. of Anatomy.)

cortex in radial branches, the course of which is similar to that of the interlobular arteries. They end in the arcuate veins, which also receive the venulæ rectæ and finally leave the kidney at the hilum. In the cat, however, a system of veins directly under the capsule receives radicles which drain the outer half of the cortex, while another system corresponding to the arcuate veins, receive short interlobular veins and also venulæ rectæ and the two systems unite at the hilus. In the dog also there are two systems of veins, but the large subcapsular system drains the outer half of the cortex and then ends in the arcuate veins, which also receive short interlobular veins and the venulæ rectæ returning the blood from the medulla.

Lymph clefts have been described in the labyrinth of the kidney, especially around the convoluted tubules and around the blood-vessels, and also around the blood-vessels of the capsules and of the medullary portion of the kidney. These unite into true lymph vessels, which are divided into superficial and deep. The former arise on the surface of the organ, as their name indicates, and pass toward the hilum. The deep vessels accompany the blood-vessels toward the sinus, where four or five are usually found, one for each division of the artery. They, with the superficial lymph vessels, pass to the lumbar lymph glands which are nearest to the hilum.

Stahr has recently reported the results of some work on the lymph apparatus of the kidney. He found two

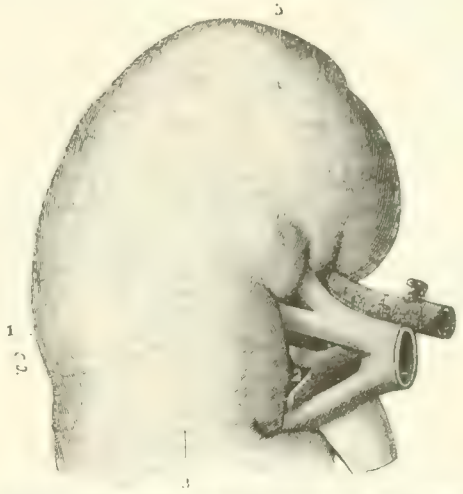

Fig. 3594.—The Venous Stars of Verheyen, seen on the Anterior Face of the Right Kidney. (Testut.) 1, External border of the kidney; 2, hilum with the renal vessels; 3, venæ stellatæ.

systems of capillaries in the capsule: one in the fatty capsule (superficial) and one in the fibrous capsule, connected to the lymph capillaries of the cortex. He finds no lymph capillaries in the glomeruli. The capillaries of the cortex, like the blood capillaries, form a network and collect at quite regular intervals in the medullary rays and pass down vertically to the border of cortex and medulla, where they form arches. These arches are in communication with the lymph vessels, which pass straight through the medullary substance.

Nerve Supply of the Kidney.—The nerves of the kidney are derived mainly from the sympathetic through the solar and aortic plexuses, the semilunar ganglia and the splanchnics. They communicate with the spermatic plexuses, and some filaments have been traced to the pneumogastrics (Morris).

The mode of distribution and termination of the nerves in the kidney has been investigated by Retzius, Kölliker, von Ebner, Berkeley, and many others. Smirnow has reported the results of his extensive investigations on these nerves by means of the Golgi method and the Ehrlich methylene blue method. He states that the nerve trunks enter the sinus renalis, partly with the blood-vessels and partly accompanying the renal ducts. These trunks consist of non-medullated nerves and medullated nerves of different caliber. These nerves form a plexus in the sinus renalis, in the meshes of which he was able to demonstrate multipolar nerve cells. He describes motor nerve endings in the smooth muscle of the walls of the renal pelvis and of the ureters, sensory free endings in the connective tissue of these structures and also interepithelial fibers. In the fibrous capsule numerous nerve fibers were found which ended partly on the blood-vessels, in which both motor and sensory endings were observed, and partly in the connective tissue. All the blood-

vessels of the kidney are provided with nerves, in many of them both motor and sensory nerve endings having been observed. From the plexus in the vasa afferentia, non-medullated nerve fibers penetrate into the glomerulus, ending partly on the capillary vessels of the glomerulus and partly in free endings on the outer surface of Bowman's capsule. In addition to the nerves supplying the blood-vessels of the kidney, there are also nerves arising from trunks which accompany the arteries, which end on the urinary tubules of both the cortex and medulla. There is a close anatomical relation between the nerves of the renal parenchyma and the vascular nerves. The urinary tubules of both cortex and medulla are provided with non-medullated nerves, which run in the sheath of the tubules, branch repeatedly, forming a plexus on the outer surface of the membrana propria of the tubules. From this plexus varicose fibers arise, which end on

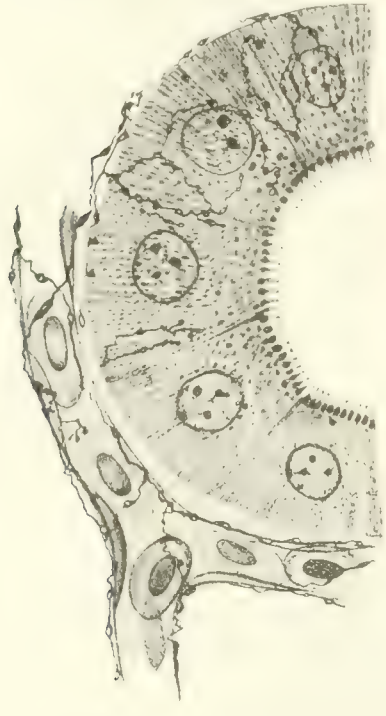

Fig. 3595.—Cross-section of a Convoluted Tubule from the Kidney of a Frog, Injected with Methylene Blue, fixed by Bethe's Method, and Counter-stained with Cochineal. In the neighborhood of the tubule are two nerve fibers, one of which passes to the wall of the tubule, while the other goes to the blood-vessel. On the epithelial cells of the tubule, varicose fibers are seen, which form free endings of different form; these epithelial nerve endings arise from nerve fibers which lie at the periphery of the tubule on the outer surface of its sheath. Around the blood capillary, varicose nerve fibers form a plexus, which forms two small endings in the walls of the capillary; one of these consists of three short fibrils and the other of two, which end in a knob. (Smirnow.)

the surface of the membrana propria (epilamellar nerve endings). From the epilamellar plexus, fine fibers arise, which pass through the membrana propria into the tubule and form, on the surface of the epithelial cells, endings of different form (hypolamellar endings). These are found in the convoluted tubules, in the straight collecting tubules, and in the main excretory ducts of the kidney. The mode of ending of the nerve fibers and the relation of the vascular and secretory nerves are shown in Fig. 3595 taken from Smirnow's report.

Thus the kidney is shown to have a large number of nerves and nerve endings, from which we must conclude that the nervous system exerts a constant influence on the excretion of the urine.

Development of the Kidney.—The development of the kidney is associated with the development and degeneration of certain fetal structures, known as the pronephros and the mesonephros. The former originates in the cells of the middle plate and consists of a long tube, the pronephric duct, and transverse tubules, which open into the pronephric duct and communicate with the body cavity. These are invaginated by glomeruli. This organ functionates as an excretory organ in certain of the lower forms, but in man it is quite rudimentary and its development is abbreviated and incomplete. It undergoes complete degeneration but for a time remains may be found in the retroperitoneum in the form of closed vesicles. The parent tissue of the mesonephric tubules is furnished by the segment stalks, which, cut out as a whole from the mesoderm, form what is termed the nephrogenic cord. In an embryo of 5.3 millimeters greatest length the nephrogenic cord is interrupted in the twenty-sixth or twenty-seventh segment, becomes looser and soon is no longer distinguishable from the surrounding tissues. Thus the cord is divided into two portions: a long cranial one, from which the mesonephric tubules develop and a short caudal one from which the metanephric tubules originate. Schreiner calls the two portions the mesonephrogenic and the metanephrogenic cords. The excretory duct connects with the cloaca. Spherical masses of cells separate off from the nephrogenic cord in the different segments, become hollowed out to form vesicles and then become connected by a principal tubule with the excretory duct. The glomerulus appears, forming the anlage of the renal or Malpighian corpuscle and the tubule begins to bend S-shape. The tubules elongate somewhat and form a loop but no convolutions. They unite to form the mesonephros, the two mesonephroi being nearly straight and parallel, the renal corpuscles being so placed one above the other that they form a column. The fully developed mesonephros contains thirty-two to thirty-four tubules consisting of a large Malpighian corpuscle, a secreting and a collecting tubule. The degeneration of the mesonephros occurs in two periods; the first begins even before the organ has reached its full extent and is finished in embryos of twenty-one millimeters greatest length. During this period, the greater part of the mesonephros, beginning at the cranial end, is degenerated. The second period comes on gradually and no definite time limits for it can be determined. Some further tubules are suppressed during this period and others enter into the service of the reproductive system.

The permanent kidney or metanephros begins to develop as early as the fifth week of embryonic life. Two distinct views are expressed in the literature regarding the development of the permanent kidney: one is that the pelvis of the kidney, collecting tubules and uriniferous tubules all develop from this evagination from the primary excretory duct. This view is upheld by Müller, Remak, Kölliker, Schweiger-Seidel, Toldt, Nagel, Minot, Gerhardt, Haycraft, Heisler, and others. This view is well summarized by Haycraft. He states: 1. That the connective tissue and blood-vessels of the kidney develop from the blastema, while the epithelium of the tubules proliferates from the cells originally lining the ureter and Wolffian duct.

2. The tubules which first sprout into the blastema terminate in dilatations, the primary renal vesicles.

3. Then these form branching cavities which always remain at the periphery of the cortex; from these the urinary tubules bud off, the older ones sinking down into the medulla.

4. The tubules which first sprout from the ureter soon become turned inside out to form the pelvis of the kidney.

5. Many of their prolongations into the rapidly dividing renal vesicles also become evaginated, thus increasing the number of tubules passing between the pelvis and the renal vesicles at the cortex.

6. Those that remain form the collecting tubules.

7. The Bowman's capsule is moulded into its shape upon the bent tubule long before the glomerulus is formed. It is invaginated rather by its tubule than by the glomerulus.

The second view is strongly supported by Kupffer, Gegenbaur, Wiedersheim, Hamburger, Schreiner, Chievitz, and Herring. Herring thus summarizes the views held by these authors: The kidney arises from two distinct structures which come together at an early period and remain intimately associated during further development.

1. *The Kidney Blastema.*—This consists of a mass of cells closely related to the blastema of the Wolffian body, and apparently formed from the intermediate cell mass or the peritoneal epithelium. It is therefore mesoblastic. It forms an envelope around the ends of the ureter branches, and persists as a thin cellular investment under the capsule and between the lobules, until the end of the eighth month, after which it entirely disappears.

2. *The Ureter.*—This structure is an outgrowth from the Wolffian duct. It appears at the end of the first month, and grows forward, as a solid column of cells, to reach and embed its peripheral branches in the kidney blastema. The balance of recent opinion is in favor of the ureter being epiblastic.

At the beginning of the second month, the ureter has come into apposition with the kidney blastema and the result is the beginning of the formation of the permanent kidney. The ureter branches early, and its lumen dilates anteriorly to form the future pelvis and calices. The primary branches are of a definite number, and at their extremities masses of cells appear constituting the "Nierenbecke" of the German writers. From these masses of cells in the kidney pelvis are developed the collecting tubules of each lobule. Ureter, pelvis, calices, and collecting tubules are formed from the Wolffian duct and these are the only parts formed from this structure, unless we include part of the intercalated tubule. From the kidney blastema arise the Malpighian bodies, convoluted tubules, Henle's loops, and the junctional tubules, the connective-tissue framework and the capsules. Malpighian bodies and their tubules begin to appear at the end of the second month, uniting at an early stage with the branches of the ureter. Each Malpighian body with its tubule arises as a solid mass of cells at the periphery of the lobule in close relation to the dilated extremity of a branch of the ureter. The solid mass acquires a lumen and assumes an S-shape. The lower limb of the S becomes a Malpighian body, the upper and middle limbs become convoluted tubules, while the bend between them develops into the Henle's loop; the extremity of the upper end joins the collecting tubule and forms the greater part of the junctional tubule. The cells lining the tubules are at first similar, but become differentiated as the organ functionates.

The careful work of Schreiner, of Stoerk and of Huber and especially the instructive and convincing series of wax plate reconstructions made by them of the developing renal tubule and its efferent apparatus, have settled beyond any reasonable question the point which has so long been debated, and the practical agreement of these three workers with each other and with Herring on the dual origin of the kidney makes the conclusion certain that the secretory portion of the kidney tubule arises as stated from the nephrogenic tissue, while the collecting tubules arise from the ureter, an offshoot of the primary excretory duct. Fig. 3596 represents a most convincing series of models of developing renal tubules from a human embryo of the seventh month as reconstructed by Huber.

The development of the permanent kidney may then be divided into two portions, the secretory or actual glandular portion and the efferent apparatus. The efferent apparatus develops from the primary excretory duct, which by an outgrowth forms on either side a ureter. This gives rise to a series of tubules, the primary collecting tubules, each of these to secondary ones, these again to tertiary ones and so on until finally there is formed an excretory apparatus consisting of collecting tubules of the first to the twelfth order and of terminal collecting tubules.

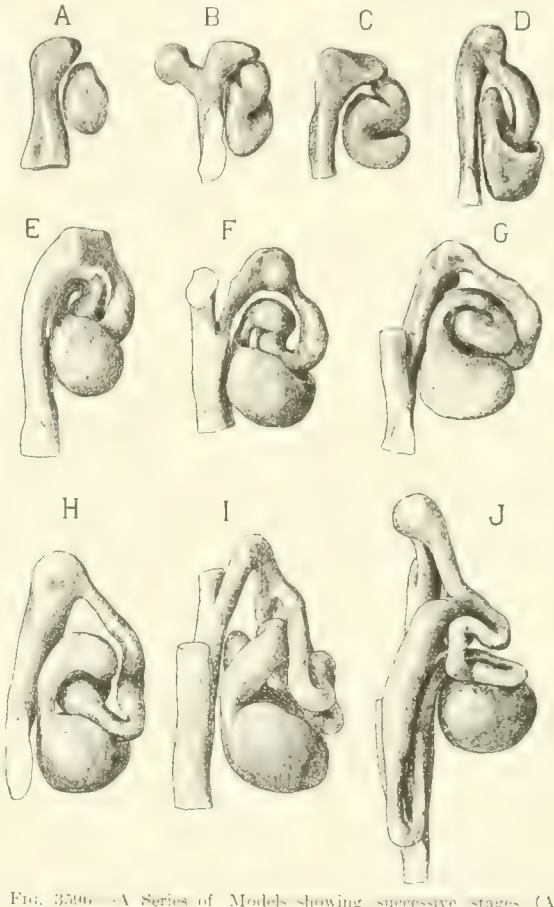

FIG. 3596.—A Series of Models showing successive stages (A to J) in development of tubular anlagen and early stages in the development of uriniferous tubules, with a portion of the collecting tubule to which each is attached; from a human embryo of the seventh month. (Huber, Am. Journal of Anatomy.)

The secretory metanephrogenic tubules develop from the posterior portion of the nephrogenic cord and unite with the terminal collecting tubules. The Bowman's capsule, first and second convoluted tubules, descending and ascending limbs of Henle's loop and junctional tubule are thus developed from the nephrogenic tissue.

II. PHYSIOLOGY OF THE KIDNEY.—Two portions of the kidney have been regarded as of primary physiologic importance and have therefore received most exhaustive study—a study which has resulted, however, in views which are most widely divergent. These two portions are the glomeruli, including the capsule of Bowman, and the convoluted tubules, including the loops of Henle. As stated under the Anatomy of the Kidneys, the glomeruli consist of branching and anastomosing loops of capillaries, between which is a small amount of reticular connective tissue, the entire structure being imperfectly divided

into lobules by strands of connective tissue. The glomerulus is covered by a single layer of much flattened epithelial cells, the glomerular portion of Bowman's capsule. Between this and the peripheral portion of the capsule is a space, which connects with the lumen of the uriniferous tubule and hence forms the beginning of this structure. We have therefore a structure analogous to that of the lungs. The blood is found in thin-walled capillaries, separated from the urinary space only by the thin wall of the capillary and a single layer of flattened epithelium—the typical condition for osmosis. The endothelium-like cells of Bowman's capsule have been carefully studied with the view of determining whether any changes of structure of these cells occur during the process of secretion, and Van der Stricht states that clear droplets of fluid have been seen by him in these cells between the granules of protoplasm. The cells lining the convoluted tubules and loops of Henle have been studied by various methods by Heidenhain, Henle, Krause, Nussbaum, Tornier, Van der Stricht, Zimmermann, Sauer, and many others. The rod structure, ciliated border (Bürstensaum), granular and vacuolated appearances of the cells have been described somewhat in detail under the Anatomy of the Kidney and need not be repeated here. Nicolas states that the inner portion of these cells is destroyed during secretion as in the cells of the mammary gland, the cells being then rebuilt from the peripheral portion of the cell. Most of these authors agree that the cells of the convoluted tubules and Henle's loops undergo certain important changes of structure, which they ascribe to the processes of secretion, the fluid being collected in the cell as granules or as vacuoles, and finally extruded into the lumen; Sauer, however, refuses to admit that the appearances described have anything to do with the processes of secretion, being found in all phases of secretion alike. These cells are in many respects like the cells lining the intestinal cavity, which are known to be absorptive rather than secretory in their function; the Bürstensaum is comparable to the striated cuticular border of these cells while the striated protoplasm is met in many types of cells, especially of gland ducts. The variations observed by different authors and even by the same author in different preparations may be, in part at least, due to different methods of fixation or to other differences of technique.

That certain portions of the urine are excreted by the glomeruli is admitted by all authors, but views differ widely in regard to how much, what constituents, and whether the process is purely physical, a process of filtration, or whether the glomerular epithelium is actively concerned in the process, so that it becomes a vital process of secretion. Many physiologic experiments have been undertaken to determine these points, and two diametrically opposed views have arisen, each of which is supported by a long line of investigators.

1. *The Bowman-Heidenhain Vital Theory.*—This theory was first formulated by Bowman in 1842 on a purely anatomical basis and it was later (1874) confirmed by Heidenhain on the basis of experimental data. It is briefly stated as follows:

"(*a*) In the kidney, as in all other glands, the secretion depends on the active intervention of special secretory cells.

"(*b*) The first type of these cells is represented by the simple layer of epithelium covering the glomerular loop of capillaries. The office of these cells is to secrete water and such salts of the urine as are found in all other parts of the body in watery solution (*e.g.* sodium chloride).

"(*c*) Another system of secretory cells, forming the lining investment of the convoluted tubules and ascending limb of the loop of Henle, secrete the specific constituents of the urine (urea, uric acid, etc.).

"Under some conditions, they may also secrete a certain amount of water.

"(*d*) The activity of the two kinds of secretory cells is determined: (1) By the amount of water or urinary constituents contained in the blood; (2) by the velocity of the blood flow through the capillaries of the kidney, inasmuch as on this factor depends the supply of oxygen and of substances to be secreted to the cells.

"(*e*) The great variability in the constitution of the urine may be explained by differences in the secretory activities of these two types of cell."

Heidenhain based his conclusions largely on the fact that after the injection of indigo carmine, the cells of the convoluted tubules and of the ascending limb of Henle's loop were colored by the dye, while the other portions of the kidney were quite free from the pigment. In the kidneys of birds, crystals of uric acid were found in the same cells by Bowman and v. Wittich, while indigo carmine, carmine, Ehrlich's tricolor mixture, and other dyes have been used by other investigators with similar results.

Dreser concludes from his observations that the production of urine is attended by the doing of work on the part of the kidney and must therefore be looked upon as a process of secretion, while Adami states that the glomerular epithelium must be looked upon as possessing powers of a selective secretory nature. Thompson decides from his experiments with atropine and morphine that the production of urine is to a certain extent analogous to the manufacture of the secretion of other glands which are influenced by atropine. Magnus and Gottlieb conclude from their experiments with diuretics that, while there is usually an increase in the blood content of the kidney, shown oncometrically, as a result of the administration of diuretics, yet diuresis may occur without a corresponding increase of the blood flow through the kidney. The increased flow of blood is regarded as an auxiliary factor in the increase of the secretion, and the diuresis may be checked by causing contraction of the renal arterioles. From these data, they conclude that "the relations between the circulation and excretion in the kidney are similar to those in the salivary glands."

2. *Ludwig's Mechanical Theory.*—In 1844 Ludwig presented his well-known theory, which is briefly formulated as follows:

"(*a*) The secretion of water is a purely mechanical process, depending only on the blood pressure in the glomerular capillaries and the permeability of the filtering membrane.

"(*b*) This dilute fluid is concentrated in the tubules by giving up its water to the surrounding lymph, in consequence of differences of concentration between the glomerular fluid and the lymph.

"(*c*) All the urinary constituents are turned out of the blood with the water through the glomeruli."

This theory depends on the connection between the circulation through the kidney and the amount of urine excreted. A mechanical filtration must depend largely on differences of pressure between the blood in the capillaries and the urine in the tubules; partly also on the rapidity of the blood flow through the glomeruli.

The blood pressure is raised: (1) By a rise of the general blood pressure; (2) by dilatation of the renal arterioles, and (3) by obstruction of the renal vein. This last factor, while it raises the pressure of the blood, will also retard the blood flow and, as shown by the work of De Souza and others, causes a diminution or cessation of the urinary excretion.

The theory, so far as the absorptive function of the epithelial cells of the tubules is concerned, is confirmed by the facts mentioned by Korányi that the concentration of the urine increases with the length of the convoluted tubules and diminishes in proportion to the rapidity with which it passes through the tubules, as after diuretics, when the urine is very dilute. Dreser decides that the work of the convoluted tubules is purely absorptive, but regards this as a vital process, because of the fact that in pathologic conditions, when the cells of the tubules are diseased and incapable of

doing work, the urine is more dilute. Korányi draws the conclusion that only the physical processes of metabolism are so far explained and that, while many facts still remain tending to confirm the vitalistic theory, these are becoming fewer and fewer, and the probability is that, with the further advance of our knowledge on this subject, physical processes will more and more predominate over the vital.

Cushney states that the relative amounts of chloride and sulphate in the urine vary independently of their proportions in the blood plasma and also of the degree in which each is present in excess, a fact which he explains by saying that the tubules alter the glomerular fluid by absorbing some of its constituents, the sulphates being absorbed with greater difficulty than the chlorides. His experiments on diuresis have so important a bearing on the settlement of this vexed question that a fuller reference to them will not be out of place here. He, in a number of experiments, injected into rabbits solutions of sodium chloride, sodium sulphate, sodium phosphate, and urea. The urine having been examined before the experiment, mixtures of two of the solutions were injected into the jugular vein, the urine being collected and examined at frequent intervals. In the first stage of diuresis after the injection of the mixture of chloride and sulphate, the chloride of the urine was to that of the plasma as 2:3, while in the last phase it was in the ratio of 1:5. The sulphate in the first phase was as 2:1, and in the last phase as 10:1. The only assumption necessary to explain these results is that the sulphates are absorbed by the tubules with greater difficulty than the chlorides, an assumption which is in accord with their behavior toward the epithelial cells of the intestine, red blood cells, and others. The precipitation of the carbonates in the normal urine of the rabbit is also better accounted for by the reabsorption of the solvent than by any other hypothesis. This absorption, however, he regards not as a simple diffusion, as Ludwig at first assumed, but there must be an unknown force causing a current from the lumen toward the blood as in the intestine. Which constituents of the glomerular fluid shall be subjected to this force, however, is determined by their diffusibility into the cells. The injection of urea resulted in similar phenomena; the percentage was high in the normal urine, fell during diuresis, and rose gradually as the quantity of urine returned to normal. The urea thus resembles the sulphates and phosphates, apparently passing through the capsules readily, but failing to penetrate the epithelium of the tubules so readily as the chloride. Cushney, therefore, explains his results in conformity with the mechanical theory of renal secretion modified by the acceptation of active absorption in the tubules. The diuretics cause a hydremia, which induces an increased flow through the capsule, the fluid carrying with it salts in the same proportion in which they occur in the plasma. The rapid flow through the tubules permits of only imperfect absorption, but a certain amount of the water and chloride are returned to the blood, while the less diffusible bodies are excreted, it may be, in a form more concentrated than in the blood. Later more perfect absorption takes place and the urine becomes more concentrated, and the proportions are changed. Cushney concludes his argument with the statement that "the epithelium lining the renal tubules is often compared to that of a true secreting gland, such as the salivary, but it resembles that of the intestine as closely histologically and in its reaction to chlorides, phosphates, and sulphates, is analogous from a physiological point of view."

On the other hand, the work of Barcroft and Brodie on the gaseous exchange during diuresis and during phloridzin glycosuria, in which they found that during diuresis, the kidney uses more oxygen than the body generally and that the amounts of oxygen used and of CO^2 given off are practically the same showing an intense chemical activity, lends no support to the mechanical theory of kidney function. Underhill, Wells, and Goldschmidt, in their experiments on tartrate nephritis, in which the tubular epithelium alone is affected while the glomeruli functionate normally, found the kidney almost impervious to nitrogen compounds, but not to chlorides; they therefore concluded that normally NaCl and H_2O are eliminated by the glomeruli while the tubular epithelium is concerned in the secretion of urea. They saw no evidence that the glomeruli could take over the urea-secreting power of the tubules, although Brodie and Cullis and also Bainbridge and Beddard, repeating Nussbaum's well-known experiments of ligating the renal artery of the frog, thus cutting off the blood supply to the glomeruli, found that by supplying abundance of oxygen, either by keeping the frogs in nearly pure oxygen as in Bainbridge and Beddard's experiments, or by injecting oxygenated Ringer's solution, as in Brodie and Cullis's work, the epithelium of the renal tubules could be preserved intact. The tubules could then apparently assume the function of the glomeruli after the injection of urea and secrete a urine containing not only urea, but also chlorides and sulphates and water.

The question at issue cannot then be regarded as decided. Some physiologists like Cullis regard the entire process of urine formation as secretory, believing that both the low cells of the glomerular capsule and the higher rodded cells of the convoluted tubules are true glandular cells functionating as secreting epithelium. The greater number of physiologists, however, prefer to take the middle ground and regard the glomerular activity as filtration while the tubular epithelium assumes two functions—the secretion of urea and like substances and the absorption of certain salts.

We may therefore conclude with Starling that according to the weight of evidence at present known the glomeruli produce by osmosis a protein-free filtrate having the same crystalloid concentration as the blood plasma, the rate being regulated by blood pressure and velocity and by colloid content of plasma. That the cells of the convoluted tubules may take up from the surrounding lymph, substances like urea, uric acid, etc., which are in excess, accumulate them in vacuoles and discharge them into the lumen of the tubules. Besides this specific secretory activity of the cells of the convoluted tubules, the tubules as a whole have the power of absorbing both water and dissolved substances from the fluid in the lumen and that the relative permeability of the cells to these constituents is at any rate one factor in determining the substances absorbed. As a result of these processes, the glomerular filtrate is greatly modified, receiving urea, uric acid, phosphates and under certain conditions water from the cells of the convoluted tubules and giving up salts, especially NaCl and generally water to the same or other cells of the tubules.

The question of renal sufficiency has recently been investigated by many workers and by various methods.

1. The functional activity of the kidney has been investigated by the use of aniline dyes, especially methylene blue; the important points observed are the time of the first appearance of the blue in the urine, the intensity of the excretion, and the duration and character of the process. All these factors vary in different pathological conditions.

2. Ureteral catheterization was then used to determine in these experiments, which kidney is functionating normally or abnormally.

3. Cryoskopie, the method suggested by Korányi, depends for its value upon the physical principles (*a*) that the osmotic pressure of a fluid is proportional to its concentration (*i.e.* to the number of molecules dissolved in a unit of volume).

(*b*) Solutions which are in proportion to their molecular weights, volume, and temperature being equal, have the same osmotic pressure.

(*c*) The freezing-point of solutions is lowered in pro-

portion to the amount of solid dissolved (*i.e.* the concentration).

Hence the lowering of the freezing-point can be regarded as the measure of molecular concentration and the functional sufficiency of the kidney can be estimated by determining the difference between the lowering of the freezing-point of blood serum and of urine.

Phloridzin, because of its power of causing the excretion of sugars in the urine, has been used to show the functional activity of the kidney from the standpoint of its glandular power.

More recently (1910) a method of determining the functional capacity of the kidney has been suggested by Rowntree and Geraghty. Phenolsulphonephthalin is administered subcutaneously and the dye in normal individuals appears in the urine in about ten minutes. This is apparently the simplest and most accurate of the functional tests yet used. The dye is non-toxic, the dose needed for the test is small and excretion is rapid if the kidneys are normal. The brilliant red color given to the urine is not modified by the color of the urine and quantitative determination can be made easily and with considerable accuracy. The test has been used by many workers since its introduction and reports of results vary so much that the method may still be regarded as on trial. It seems, however, to have many characteristics which make it a distinct improvement over the methods previously used.

The urine is a fluid of very complex composition, excreted by the kidney and representing many of the end products of tissue metabolism in the body. Its composition is shown in the following tables taken from Schäfer's "Text-book of Physiology":

I. Parkes' table showing normal twenty-four hours' excretion of main urinary constituents.

	Percentage composition of solids.	Absolute weight in grams.	Weight per 1,000 of body weight.
Urea, CH_4N_2O	45.75	33.18	0.5000
Creatinin, $C_4H_7N_3O$	1.25	0.91	0.0140
Uric acid, $C_5H_4N_4O_3$	0.75	0.55	0.0084
Hippuric acid, $C_9H_9NO_3$	0.55	0.40	0.0060
Pigment and other organic substances	13.79	10.00	0.1510
Sulphuric acid, SO_3	2.77	2.01	0.0305
Phosphoric acid, P_2O_5	4.36	3.16	0.0480
Calcium	0.35	0.26	0.0004
Magnesium	0.28	0.21	0.0003
Potassium	3.45	2.50	0.0420
Sodium	15.29	11.09	0.1661
Chlorine	10.35	7.50	0.1260
Ammonia	1.06	0.77	0.0130
	100.00	72.54	1.1057

II. A table derived from Bunge, representing the twenty-four hours' excretion of a young man, upon a diet consisting in one case entirely of beef with a little salt and spring water; in the second case of bread with a little butter and with some water.

	Meat diet.	Bread diet.
Amount of urine in twenty-four hours	1672 c.c.	1920 c.c.
Urea	67.2 gm.	20.6 gm.
Creatinin	2.163 gm.	0.961 gm.
Uric acid	1.398 gm.	0.253 gm.
Sulphuric acid (total)	4.674 gm.	1.265 gm.
Phosphoric acid	3.437 gm.	1.658 gm.
Lime	0.328 gm.	0.339 gm.
Magnesia	0.294 gm.	0.139 gm.
Potash	3.308 gm.	1.314 gm.
Soda	3.991 gm.	3.923 gm.
Chlorine	3.817 gm.	4.996 gm.

III. The differences between the excretion of certain constituents of the urine by males and females respectively is indicated in the following table, given by Yvon and Berlicz:

	Male		Female	
	Per hour.	Per diem.	Per hour.	Per diem.
Specific gravity		1.0225		1.0215
Volume		1360 c.c.		1100 c.c.
Urea	21.5 gm.	26.5 gm.	19.0 gm.	20.5 gm.
Uric acid	0.5 gm.	0.6 gm.	0.55 gm.	0.57 gm.
Phosphoric acid	2.5 gm.	3.4 gm.	2.4 gm.	2.6 gm.

A human adult usually excretes from 1,200 to 1,700 c.c. of urine in twenty-four hours and the specific gravity varies from 1.015 to 1.025, and is in general inversely proportional to the amount excreted.

Normal urine gives an acid reaction, the acidity being due to the fact that neutral constituents of the food give rise to acid end-products in metabolism. The sulphur of proteins is converted into sulphuric acid and the phosphorus of lecithins into phosphoric acid. There is thus a preponderance of acid radicles over bases in ordinary urine. This, however, is true only of man and the carnivora. In herbivora, the vegetable acids undergo oxidation to carbonic acid, which with the alkaline bases forms alkaline carbonates. Such urines are therefore alkaline in reaction and the human urine can be made alkaline by the ingestion of large quantities of vegetables or fruits. Dreser and others concluded as the result of their experiments that the urine, as it passes through the glomeruli is alkaline, and that the change to the acid reaction is brought about in the cells of the convoluted tubules. Diuretics often cause alkalinity. The change in reaction may be the result either of the secretion of acid salts or the absorption of alkaline salts, by the cells of these tubules.

The degree of acidity is a resultant of two opposing factors: (1) acid production in metabolism; (2) the ingestion of unsaturated or unstable basic compounds, together with the production of ammonia. To these should be added the elimination of acids or bases by other channels than the kidney. Thus the acidity increases with increased protein metabolism, with exercise, and with the consumption of food containing but a small amount of the bases, especially flesh food. It diminishes when the food contains abundant bases. This explains the fact that the urine of herbivorous animals is alkaline, while that of man may become alkaline, at least for a time, when a vegetarian diet is maintained (Hopkins).

Urea.—By far the greater part of the nitrogen eliminated from the body is eliminated in the form of urea, a nitrogenous substance first demonstrated by Rouelle in 1773. It is derived by the metabolism of proteins and is the most important index to the protein metabolism of the body. The proteins form ammonium carbamate, which is changed by the liver cells into urea. This was shown by the experiments of Schroeder, Schöndorff, and others. They found that by passing the blood of a dog through the vessels of the liver, there was a marked increase of the urea present; this did not occur if the blood were passed through the vessels of the kidney or other organs. If the liver was removed, as shown by the experiments of Hahn, Pawlow, Masson, and Nencki, carbamates appeared in the urine, with a corresponding decrease in the amount of urea. Some urea is, however, found in the urine, after removal of the liver, so it is probable that some other organs have the power of forming urea, though to a much less degree than the liver. While urea is neutral to litmus, it exhibits weak basic properties and forms loose compounds with acids, so that urea nitrate, urea oxalate, and urea phosphate are

met. About thirty grams of urea are excreted in the urine in twenty-four hours, but the amount varies with the amount of protein taken as food and is also increased by any condition, such as fever, which causes a rapid disintegration of the tissues. Urea itself crystallizes in the form of colorless needles or rhombic prisms, while its salts crystallize in various forms.

Creatinin is a crystalline nitrogenous substance found constantly in the urine. It is derived partly from the creatin in the meat eaten and partly from the destructive metabolism of the tissues of the body. As not nearly all the creatin taken into the body is excreted as creatinin, it is probable that a portion of the creatin is changed to urea. It is said to be increased during febrile conditions and as a result of violent muscular exercise.

Uric acid is found constantly, but in relatively small quantities in the urine of mammalia, while in birds it forms the main urinary constituent, occupying the same place with them that urea occupies in the human urine. In birds it has been shown that the uric acid is formed in the liver, as the urea is in mammalia. It has been suggested that uric acid represents an end-product in the metabolism of leucocytes and the spleen has been suggested as the place of its formation. Neumeister states: "The spleen stands in close relationship to uric-acid formation, as is evident from experiments on animals and from pathologic observations. This function is simply explained by the richness of the spleen in leucocytes and therefore also in cell nucleins, from the decomposition products of which—the nuclein bases—uric acid seems to arise, at least in mammalia." The same observations were made by Hammarsten, Horbaczewski, Spitzer, and others. Mendel and Jackson, however, working on splenectomized animals concluded that the "spleen is by no means the chief organ involved in uric-acid production in the living body, if indeed it normally plays any part whatever in this process. After the exclusion of the liver and spleen, it is natural to turn to other forms of lymphoid tissue, and the lymphatic glands are at once suggested. It might be supposed that after splenectomy these glands would take up the work of the spleen. Enlargement of the lymphatic glands has been recorded after removal of the spleen in man But the investigations of Vincent, made to ascertain this fact in the dog, fail to bring to light any permanent hypertrophy of the lymphatic glands after splenectomy. It seems improbable, therefore, that the formation of uric acid in mammalia can be assigned at present to any definite organ or group of organs. While the amount of uric acid present in the urine is small, it is of considerable importance from the pathologic point of view, since it is increased in certain pathologic conditions. It is also increased when foods are ingested rich in nucleins, such as liver or sweetbreads, or in any other precursors of uric acid, *e.g.* hypoxanthin. The purin bases, xanthin, hypoxanthin, and adenin, which are analogous to uric acid, are found in the urine in variable but small amounts.

Hippuric acid occurs in the normal urine in small amount, the quantity varying with the diet. It is derived[3] from benzoic acid or from an aromatic substance which can be oxidized to benzoic acid. It is not entirely eliminated even in starvation, however, so that it arises in part also from the metabolism of the tissues. A fruit diet increases the amount, and an herbivora it is present in much larger amounts.

Albumin in traces may be present in the normal urine, arising probably from the surface of the urinary tract. This is not, however, sufficient to react to the ordinary tests for albumin. After violent exercise an appreciable quantity may appear in the urine.

Normal urine has been found to contain also not only glucose, but also a sugar of the maltose type, known as isomaltose.

Oxalic acid is found in small amounts, arising, as was recently shown by Lommel, partly from the oxalic acid in the food and partly from the carbohydrates in the food. He states that there is no direct relation between oxalic-acid excretion and protein metabolism, and that food rich in nuclein increases both the uric acid and the oxalic acid in the urine.

The inorganic constituents of the urine are derived mainly from the food, and the amount and the form in which they are excreted are therefore very variable. A portion of the sulphuric acid occurs in the form of conjugate sulphates, the acid radical being combined with an aromatic base, so that we find indoxyl and skatoxyl sulphuric acid. About nine-tenths of the sulphuric acid occurs in the form of ordinary sulphates, the relation being changed as a result of abnormal putrefactive changes in the body and also when a larger amount of the aromatic bodies are ingested.

Phosphates and chlorides are also excreted in varying amounts and combinations. The amounts vary with the food and also with the different pathologic conditions.

In closing, I would call attention to some experiments performed by Bradford to show the result of the excision of larger or smaller portions of one or both kidneys. He states that the excision of portions of one kidney is followed by an increase of the amount of urine, without an increase of the solids of the urine. The excision of about three-fourths of the total kidney weight is followed by a very great increase in the amount of urine and also an increase of the amount of urea excreted. The increased output of urea is, however, effected by the excretion of very large amounts of water, the urine not being concentrated. After excision of large portions of the kidney substance, there is a considerable increase in the nitrogenous extractives in the blood and tissues, especially in the muscles, the quantity being too great to be accounted for by the mere retention of the products of normal metabolism. These experiments, as well as some performed by other investigators, have suggested the possibility of an internal secretion from the kidney, the cessation of whose action causes the muscles and other tissues to break down and liberate urea. Boyd recently reported the results of the excision of large portions of the medulla of the kidney, in which he states that there was no increase in the secretion of urine or of urea, and no increased metabolism of the tissues. If the conclusions of both these observers are to be relied upon, it would seem to indicate that the increased metabolism reported by Bradford is due to some change, possibly the withdrawal of an internal secretion, brought about by the loss of the cortical substance of the kidney. LYDIA M. DE WITT.

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Kidneys, Anomalies of the.—Under this heading are included deviations from the normal position, size, shape, and number. Several of these anomalies may be combined; for instance, the horseshoe kidney is usually dislocated. Aside from their anatomical, embryological, and pathological interest, the developmental and congenital defects of the kidneys and ureters have a special significance. Because of their relative frequency—Motzfeldt in 4,500 autopsies found seventy-nine deformities of the urinary apparatus, 1.75 per cent.—they must be considered in every problem of surgical interference and in addition the anomalous condition may predispose to the development of disease. In this article attention is paid chiefly to the congenital variety. The acquired anomaly is frequently recognized during life, the congenital very seldom, since there may be an entire absence of symptoms.

Malformations.—Newman classifies the malformations of the kidney as follows: A. Displacements without mobility. (1) Congenital displacement; (2) congenital displacement with deformity; (3) acquired displacements. B. Malformations of the kidney. (1) Variations in number: (a) supernumerary kidney; (b) single kidney, congenital absence of one kidney, atrophy of one kidney, absence of both kidneys. (2) Variations in form and size: (a) general variations in form, lobulation, etc.; (b) hypertrophy of one kidney; (c) fusion of two kidneys, horseshoe kidney, sigmoid kidney, disc-shaped kidney. C. Variations in pelvis, ureters, and blood-vessels.

A. An otherwise normal kidney may be found in various abnormal positions. It may lie on the vertebral column, either on its own or on the opposite side. It is usually in the neighborhood of the promontory of the sacrum, seldom rising as high as the fourth lumbar vertebra; but on the other hand, in a few cases, it is situated deep in the pelvis in the concavity of the sacrum. According to Kupfer, these anomalies depend on a deficient energy in the movements of the embryonic rudiments of the kidneys, which up to a certain time are situated immediately in front of the point of bifurcation of the aorta. Congenitally dislocated kidneys are usually altered in form. They may be flattened, roundish and sometimes three- or four-cornered. The hilus is directed forward. Fetal lobulation of the surface is usually strongly marked. It occurs chiefly in men—and the left kidney is more often affected than the right. It is impossible to differentiate a congenital displacement from a floating kidney which had become fixed later in life. The practical importance of this abnormality is slight. A deep-seated kidney might be mistaken for a tumor in the pelvis. A complete rectal examination should help clear up the diagnosis.

B. *Anomalies in Form and Size.*—Secondary alterations in the form of kidneys are, of course, very frequent and are produced by numerous diseases of the kidney itself, such as cysts, abscess, hydronephrosis, chronic nephritis, new growths and by tumors of neighboring organs, etc. Congenital anomalies of this type not infrequently predispose to disease conditions such as hydronephrosis, pyonephrosis, and calculus formation. Tuberculosis, neoplasm, and nephritis occur with comparative rarity.

As examples of congenital alterations in form may be mentioned:

(1) *The Lobulated Kidney.*—On the surface of this organ there are shallow grooves, which mark the boundaries of the various renculi. This is a relic of the fetal condition, which usually disappears soon after birth, but sometimes persists. From seven to twenty renculi are found in the state of permanent lobulation.

(2) *Horseshoe Kidney.*—This type represents a combination of anomalous form and position. The fusion of the two kidneys occurs at three points according to which this variety of deformity is divided into three classes. (a) The most common anomaly is where the fusion takes place at the lower ends of the kidneys. This represents the pure type of the horseshoe kidney (ren unguiformis, renes arcuati; ren soliformis). The concavity looks inward and upward.

(b) The second form is not so common. In it the union takes place in the middle between the two hila. There may be only a thin bridge of tissue between the two kidneys.

(c) The third form is the rarest. The fusion takes place at the upper end.

In the highest grade of this variety, the fusion may involve almost the entire kidney, leaving only the lower end free; at times they are separated by only a shallow depression. The fusion may be such as to give the kidney a sigmoid or disc shape.

These anomalous forms of kidneys may prove of surgical interest from the standpoint of diagnosis and operative treatment. Landwith mentions a case in which this condition was mistaken for a dilatation of the abdominal aorta. In another case, as a result of congestion of the fused kidney, a compression was suddenly exerted upon the underlying vessels, which caused a thrombosis of the large veins; death resulted from a complete arrest of the circulation. Previous to this time, although the isthmus lay over the abdominal aorta and inferior vena cava, it was raised with each arterial pulsation, thus lessening the pressure on the vena cava.

The anomalous form and position of the kidneys may, under certain circumstances, be responsible for interference with the escape of urine with a fatal termination. Such a case has been reported by Koster—the pregnant uterus pressed upon the displaced ureter causing a pyelonephritis.

B. von Langenbeck has seen children die suddenly with brain symptoms, probably uremic, in whom a horseshoe kidney was found at autopsy.

These kidneys are usually found in abnormal positions, even in the true pelvis, lying in the cavity of the sacrum. Sometimes they are on one side and may present nodular, irregular masses in which inflammation and suppuration may occur.

In any case of a single kidney the possibility of it being a fused kidney must be considered. Bachhammer gives the following means of distinguishing between them. In the single kidney with two ureters, they open either individually, or after fusion, into the same side of the bladder. A fused kidney has two ureters which open into the bladder normally.

Most cases of crossed dystopia occur in males. It does not predispose to disease. In sixty per cent. of cases the right kidney was displaced. The frequency of the anomaly is very small. Morris noted its occurrence only once in 14,318 autopsies performed at different London hospitals. It is due primarily to a fusion of the two metanephric blastemata, the dystopia being a result of this. Each ureter has its own clientèle of pyramids.

(3) *Absence of One Kidney.*—We sometimes meet with cases in which one kidney is entirely absent. These must not be confounded with cases in which there is great congenital atrophy of one kidney dependent on rudimentary development of renal vessels.

When the kidney is entirely absent, the corresponding ureter will be invariably absent. It is a rare thing for the ureter of a solitary kidney to cross over to the opposite side before it opens into the bladder. There is usually no disturbance in the renal function. The kidney is hypertrophied and thus takes upon itself the work of two kidneys. Following a nephrectomy the remaining kidney undergoes hypertrophy. If, however, it should become involved in disease, or the ureter should be obstructed by a calculus or compressed by a tumor, very alarming symptoms supervene. In twenty-four cases in which the cause of death is given, in twelve it was due to the anomaly; in ten it was due to the presence of renal calculi plugging the ureter, in two to pressure on the ureter by cancerous tumors. In operations upon the kidney the surgeon should make certain that his patient has more than one kidney. The fused kidney is most likely to deceive the surgeon; it is enlarged and displaced and may be mistaken for a new growth. In Polk's case the organ was removed under the belief that it was a floating kidney. The patient lived eleven days, had complete anuria, and it was found postmortem that the patient's only kidney had been removed.

The cystoscope has proved of great value in diagnosing the presence of two kidneys. It could not, however, exclude the fused kidney, since in this variety the two ureters might open into the bladder in the normal manner.

Ballowitz found in 205 cases of absence of one kidney that in fifty-seven per cent. it was the left that was lacking.

(4) Congenital absence of both kidneys is an extremely rare condition, occurring only with extreme defect of development. It is, of course, incompatible with continued existence.

(5) In a few exceedingly rare cases of fused kidney, the supernumerary renal parenchyma is not united to the two kidneys, so that the middle piece constitutes an independent kidney, which receives blood from both lateral parts, but also possesses in part independent vessels.

C. *Variations in Pelves, Ureters, and Blood-vessels.*—When only a single kidney is present there may be one or two pelves and one or two ureters. These may open separately or they may fuse and have but a single opening. It is a rare thing for the ureter of a solitary kidney to cross over to the opposite side before it opens into the bladder. In the different varieties of fused kidneys, the veins and arteries are usually abnormal, both in number and in position. Branches frequently pass to the kidneys from one or both of the common iliac arteries. The hila occur on the anterior surface in the majority of cases, consequently the ureters pass in front of the kidneys. In the different varieties of congenitally dislocated kidneys the renal and neighboring vessels have anomalous origins, their number is usually increased, and they are shorter than normal. The ureters are also shortened and run an anomalous course. As an illustration of an unusual abnormality may be mentioned the presence of Müller's duct.

Congenital cystic kidney is perhaps not strictly speaking, an anomaly but certainly deserves mention in this place. It is of importance since it is not infrequently mistaken for a new growth. It is easily recognized at operation and should never be removed.

Diagnosis.—Aside from movable kidney which has been considered elsewhere, the question of anomaly should be considered in the diagnosis of every surgical condition of the kidney. At the present time we have many means at our command to help in the making of such a diagnosis and if necessary all should be employed. In addition to the usual inspection, palpation, and percussion of the routine physical examination, advantage should be taken of rectal examination, röntgenography and pyelography, the injection of drugs such as phenolsulphonephthalein, cystoscopy, chromocystoscopy, and catheterization of the ureters and distention of the colon. Finally at the time of operation a direct inspection of the organ may be made and in case of nephrectomy the other kidney should be felt. Any congenital anomaly of the genital organs should cause a suspicion of the urinary tract for anomalies of these two systems are very frequently associated.

James Rae Arneill.
Revised by Ralph G. Stillman.

Kidneys, Calculous Disease of the.—*Synonyms:* Nephrolithiasis, Stone in the Kidney.

This disease was recognized long before the beginning of the Christian era. Hippocrates, about 400 B.C., not only accurately described many of the signs and symptoms of stone in the kidney but referred to operative treatment and is himself believed

to have operated for calculous pyonephrosis. Medical literature of later centuries contains occasional references to operations for stone in the kidney, and there is no doubt of the authenticity of the report that in the seventeenth century an Englishman at Venice was successfully operated upon for calculous pyonephrosis by Marchetti of Padua. This was the type of operation undertaken for the relief of nephrolithiasis even up to the middle of the nineteenth century. In the latter half of the nineteenth century the surgery of the kidney rapidly developed. In 1869, Simon, of Heidelberg, performed the first nephrectomy, and, shortly after this, nephrectomy for stone was done by several surgeons; in October, 1880, Henry Morris did the first nephrotomy for the removal of a calculus in a supposedly comparatively healthy kidney; Czerny, in 1880 (Pels-Leusden[1]) or 1881 (Kelly and Burnam[2]) removed a pelvic stone by pyelotomy; in 1881, E. Hahn, of Berlin, established the operation of nephropexy; while progress in renal surgery since those epoch-making contributions has been truly remarkable.

While calculi may form in any part of the urinary tract, by far the greater proportion are found in the kidney. Numerous minute particles of uric acid, acid ammonium or acid sodium urate, or of calcium phosphate or carbonate may be deposited in the renal parenchyma, forming uric acid or lime infarcts. These seldom result in true calculus formation. The calculi of appreciable size, which concern the surgeon, are formed in the papillæ, calices, and pelvis. These concretions are called renal calculi, and the disease nephrolithiasis, to denote the specific section of the urinary tract in which they develop. Strictly speaking, they are urinary calculi, for they are not formed directly by the renal parenchyma but are composed of materials derived from the *product* of renal activity—the urine. These stones may become dislodged while still of minute size and be passed with the urine, in the form of sand or gravel, without being discovered unless the urine is examined after the sediment has been deposited. In other cases stones become dislodged after having attained an appreciable size and pass through the ureter easily or with difficulty and with more or less discomfort to the patient. Upon reaching the bladder such a stone may be passed with the urine or remain and form the nucleus of a vesical calculus. In other instances a stone may become lodged at a constricted portion of the ureter, partially or completely blocking its lumen. Under such circumstances dilatation always takes place above the point of impaction, and either (1) the stone is gradually forced down into the bladder, or (2) a channel is established alongside the stone by which urine passes, or (3) the ureter remains blocked completely, hydroureter and hydronephrosis develop, usually sooner or later to be followed by infection and pyonephrosis with ultimate destruction of the parenchyma if operative relief is too long delayed. Finally, stones may remain fixed at the original site of formation in the papillæ or calices, or slip to the renal pelvis and continue their development in that situation, while others may develop entirely in the pelvis and remain there. The development and retention of calculi in the pelvis and calices almost invariably lead to more or less severe subjective and objective symptoms, interference with function and impairment of kidney structure, the details of which will be considered in due course.

Etiology.—Renal calculi have been called *primary* when their exciting cause cannot be determined, and *secondary* when due to bacterial invasion of the renal pelvis and calices. In spite of much clinical and experimental investigation to determine the causation of stone formation we are still far from a satisfactory solution of the problem. Most renal calculi are composed of uric acid, or of certain salts of sodium, potassium, calcium, ammonium, and magnesium, or of combinations of these substances, all of which are normally found in the urine. The degree of concentration of the urine varies in every individual, not only from day to day but at different periods of the same day, and why precipitation takes place and why the precipitated particles coalesce in one case and not in another still remains shrouded in mystery. Numerous theories have been advanced. Ebstein demonstrated an albuminous framework in renal stones whose origin was ascribed to a catarrhal condition of the renal epithelium; but it was shown later that an albuminous framework is present in all precipitates in the urine. Another theory suggested the presence of a foreign body to act as a nucleus, such as bacteria, agglutinated blood or pus cells, parasites or shreds of tissue, and occasionally such a nucleus has been demonstrated. Without doubt infection of the pelvis and calices may favor the formation of stone and the occasional cellular nucleus may thus be accounted for. Usually, however, this order is reversed and the nucleus is derived from the deposit of a temporary excess of one of the normal constituents of the urine, the infection occurring later if at all. Rovsing, quoted by Kelly and Burnam,[2] suggests that there may be a congenital or acquired diathesis in which an excessive amount of certain salts is secreted; while from time immemorial the gouty and rheumatic diathesis has been mentioned as an underlying factor. Spinal injuries have often been followed by stone formation, possibly due to bacterial invasion of the pelvis or secreting structures. Finally, sedentary habits, alcohol, certain articles of food, particularly those rich in proteins, and the composition of the drinking water in certain localities, have been considered predisposing factors. The influence of heredity has not been considered of much moment, and yet it is interesting to note that Leroy d'Etiolles, quoted by White and Martin,[3] records the fact that a family of eight brothers, who lived in various parts of Europe under different conditions of hygiene, all had calculi. One of the most remarkable facts in connection with the occurrence of renal calculi in the different races is reported by Kelly and Burnam. They state that in spite of the large negro population of Baltimore, not one of those treated at the Johns Hopkins Hospital Clinic has ever shown stone in the kidney. Outside of this observation, the geographical location seems to be a more important factor than the race of the individual. There are certain portions of Europe where stone in the kidney seems to be especially common, particularly that section of England referred to by Osler as the "stone counties." Males are said to be much more frequently affected than females, although in statistics covering a large series of cases in general hospitals the difference in percentage is not great. Formerly the greater number of cases were said to occur in the early and late periods of life; but coincident with the improvement in diagnostic methods and operative technique it has been found that the majority of cases coming to operation correspond to the early adult and middle periods—twenty to forty-five.

Renal calculi vary greatly in size. The smallest are often called *sand;* those corresponding to a medium-sized pin head are called *gravel;* while all those still larger are comprised by the term *stones.* These latter range in size from small shot up to that of the so-called coral stones filling the entire pelvis and calices. Most renal calculi fall into one of three divisions, based on their composition: (1) uric acid and urates; (2) calcium oxalate; and (3) calcium and triple phosphates. Rarer forms are, in order of frequency, those composed of calcium carbonate, cystin, xanthin, or indigo. Uric acid, urate, and calcium oxalate calculi are developed in acid urine, the phosphatic when the urine is alkaline. A calculus may consist of one of these substances or a com-

bination of several, in accordance with the varying conditions existing during the course of its formation. Hence we may see calculi with a uric acid center, as the most frequent nucleus, then a layer of calcium oxalate, with an outer layer of phosphates. The pure uric acid and urate stones are a dull grayish red or brown color, are very hard, usually have a smooth surface, and seldom reach a very large size. Oxalate stones are usually small, are extremely hard, have a reddish, brown, or black color and a very rough surface, forming the so-called "mulberry" stones. Phosphatic calculi are found of all shapes and sizes, the enormous coral stones being composed largely of this material. The surface may be smooth or granular; the color usually a dirty gray. They are comparatively soft, are brittle and easily fragmented when attempting their removal. While the cut surface of the uric acid and oxalate stones shows fairly regular concentric layers, the cut surface of pure phosphatic calculi often shows that the deposit has occurred in no definite order, while as a secondary deposit different portions of the primary calculus may be encrusted to varying degrees with the phosphates, which show an amorphous or lamellated arrangement. When more than one calculus is present in a cavity the contact surfaces are usually facetted, and this is especially true of those composed of phosphates. The number of stones found in a kidney varies from one to several hundred. In approximately one-half of the cases a solitary stone is found. The right kidney is affected a little more frequently than the left. Statistics show wide variation in the frequency of bilateral involvement, the figures in different series ranging from 16⅔ to 50 per cent. Probably 25 to 30 per cent. would be a fair estimate.

Pathology.—The pathological changes in the kidney produced by stone depend upon a number of factors, among which are: the immediate exciting cause of stone formation, its size, shape, and location, its fixity or mobility, and the presence or absence of infection. A stone composed of uric acid, urates or oxalates, remaining at rest attached to adjacent tissues in a situation where it cannot interfere with urinary outflow, may cause no appreciable anatomic changes or functional derangement as long as the urine remains acid and there is no infection. With change of one or more of these conditions, pathological changes may take place in the kidney ranging all the way from slight local degeneration of parenchyma and interstitial nephritis to complete destruction of the secreting structures. In the absence of infection or interference with the urinary outflow, general interstitial nephritis is one of the most frequent changes noted in the kidney, especially when there are several foci of stone formation. Often there is also a fibrofatty change in the capsule and perinephritic tissues, as emphasized by Israel, and sometimes this process extends to the parenchyma itself resulting, in occasional instances, in the transformation of practically the entire organ into a fibrofatty mass. Interference with urinary outflow may occur at a single calyx, in which case cysts may develop, or at or below the ureteropelvic junction, with resulting intermittent or permanent hydronephrosis, while with the advent of infection there may be pyelitis, pyelonephritis, pyonephrosis, and perinephritic abscess.

With unilateral calculous disease the other kidney is affected to a greater or lesser extent, as a rule, depending upon the amount of impairment of the calculous kidney and the presence or absence of infection. With some impairment and without infection the change in the opposite kidney is simple hypertrophy; with infection, mild or severe parenchymatous degeneration takes place in the previously healthy kidney because of the constant presence of toxins in the blood passing through it, or it may in turn become infected, while aseptic stone formation or septic infection with the development of secondary calculi are by no means uncommon.

Symptoms.—The classical symptoms are pain in the lumbar region, often radiating downward, and hematuria. Other common symptoms are: vesical irritation, anuria, tenderness with occasional palpable enlargement of the kidney, and, if infection has taken place, pyuria. It is, however, a well-known fact that one or more stones may be present in the kidney for years without giving symptoms sufficient to attract the patient's attention. It is also rather unusual to find all the above symptoms combined in one patient; and it must be borne in mind that any one or all may occur from other renal lesions entirely independent of calculus formation.

The *pain* which has been considered characteristic of stone in the kidney occurs in attacks of so-called renal colic. In these the pain usually starts in abruptly in the region of the affected kidney, is of an agonizing character, radiates down the ureter to the testicle or ovary and inner side of the thigh, is accompanied by marked prostration, often with chills, fever, nausea, and vomiting, and may be uncontrollable by even unusually large doses of morphine. In some attacks the pain may radiate upward toward the shoulder, to the region of the appendix or gall-bladder, toward the opposite kidney, or remain localized. The duration of these attacks may be a few minutes or several hours. They may follow exertion, a sudden jar, a blow in the loin or may arise without apparent cause. They occur sooner or later in about 50 per cent. of the cases and these patients may have one or innumerable attacks. Braasch,[4] in a clinical study based upon the histories of 251 patients operated upon for renal stone at the Mayo Clinic, found that hematuria and acute pain referred to the area of the kidney with anterior and downward radiation was present in 46 per cent. of the cases. Kelly and Burnam found that 46 per cent. of their cases gave a history of pain that was solely in the form of attacks, while 11 per cent. had occasional attacks but continuous pain. H. Cabot[5] found a history of colic in 54 per cent. of his cases. In a certain proportion of the remaining cases which come to operation (Braasch found 8 per cent.) pain is absent or very slight. In the others the character and location of the pain are very variable. It may be localized in the region of the diseased kidney, where it may be continuous or intermittent and vary from a dull ache to pain of the most severe type, or it may be referred elsewhere, particularly to the region of the appendix, gall-bladder, or lower part of the abdomen. Occasionally with unilateral disease pain may be referred to both kidney regions; while in rare instances the pain has been referred solely to the sound side. The pain often varies in severity in almost direct proportion to the degree of activity of the patient, being slight when at rest but almost unbearable if work is attempted.

Hematuria is the most constant of all the symptoms of renal stone, occurring at some time and to some degree in practically every case. In Braasch's series blood was found microscopically in 91 per cent. of the cases. The hemorrhage may be microscopical for long periods of time, is usually slight in amount but occasionally is very severe. In Kelly and Burnam's series there was sufficient bleeding to be noted by the patients themselves in 50 per cent. of the cases, while it was observed by 56 per cent. in the series reported by Braasch. When marked bleeding occurs it is almost invariably associated with attacks of renal colic or exacerbations of pain. This is well shown by Braasch's statistics, for of the 141 patients reporting having noted blood in the urine it occurred with typical renal colic in 106 cases, with indefinite pain in twenty-four, and without any pain in but

eleven cases. Activity of the patient usually increases the amount of hemorrhage. With an attack of renal colic the pain may disappear abruptly but the hemorrhage *gradually* lessens under the influence of rest. There is nothing characteristic about the hemorrhage of renal calculus, for it may be found in similar amounts, with and without pain, in many other pathological conditions of the kidneys. When there is no infection of the kidney or bladder and no dilatation of the pelvis the blood cells appear fresh. Clots are seldom seen unless there has been a temporary blocking of the ureter or the hemorrhage is unusually severe.

Vesical and urethral irritation may occur with or without infection of kidney, ureter, or bladder and the symptoms vary greatly in severity. There may be a slight feeling of discomfort at the neck of the bladder or end of the urethra at the close of urination. In other cases there is marked urgency, frequency and pain on micturition, though these symptoms are seldom so severe as in most cases of renal tuberculosis. Occasionally there is merely a slight, though rather persistent, pain in the bladder.

Anuria of short duration and of no special prognostic significance occurs not infrequently coincident with attacks of renal colic, the kidneys resuming their function upon cessation of the acute pain. When anuria persists, which is, fortunately, a comparatively rare occurrence, it is always one of the gravest of symptoms. Formerly it was thought that when continued suppression occurred the ureter on the opposite side must also be blocked, or that the patient had a solitary kidney, or that the other kidney was so diseased as to be functionless; but in recent years it has been proven that the suppression may also be of reflex origin. Numerous reports of clinical cases as well as experimental work might be cited in proof of the accuracy of this conclusion. It is true that usually the other kidney is more or less diseased but reflex anuria may occur even when it is apparently sound. If not soon relieved spontaneously or by medical or surgical measures death is, of course, inevitable.

Pyuria is a frequent symptom and appears with the advent of pelvic infection if the path to the bladder is not obstructed. At first slight in amount and appreciable only with the microscope, as the process advances pus soon becomes plainly apparent and may finally be present in great quantities. With these cases there will always be a variable number of red cells, some of which are much faded and known as "phantom corpuscles." In the absence of symptoms of cystitis, usually the ordinary chemical and microscopical examination of the urine is sufficient to determine the renal origin of the pus; but when bladder symptoms are present cystoscopy may be required, perhaps with ureteral catheterization. Sometimes the urine suddenly becomes clear due to the plugging of the abscess cavity or of the ureter, all the urine then coming from the unaffected kidney. When this occurs, and in the absence of renal colic, massage of the kidney, if this is possible in the individual case, will often cause the expulsion of thick masses of pus followed by urine of the usual purulent character. With the onset of infection, particularly with pyonephrosis and perinephritic abscess, there may be chills, fever, and other evidences of systemic infection. The infecting organism most frequently found is the colon bacillus; among others, staphylococci and streptococci, the proteus, typhoid, and tubercle bacilli and, rarely, the pyocyaneus.

Diagnosis.—While occasionally renal stone never gives symptoms sufficient to call attention to the condition, it is rare that one or more of the above symptoms do not appear at some time in the course of calculus formation. Sometimes without any premonitory symptoms its presence is disclosed by a severe attack of renal colic; sometimes a persistent dull ache in the loin or the appearance of blood in the urine excites suspicion of stone in the kidney, or possibly the patient consults his physician for supposed bladder trouble and the true situation is discovered in the course of a thorough examination. Many times an examination of the urine for life insurance or in the course of an attack of some minor ailment has disclosed a trace of albumin, microscopic blood and large quantities of uric acid or calcium oxalate crystals. It may then be found that there have been vague feelings of discomfort in the loin, or one kidney may be found tender on palpation or sensitive to fist percussion by Murphy's method, or the absence of other elements suggestive of nephritis may cause the physician to insist upon radiography of the urinary tract. The presence of any of the above symptoms call for careful and complete examination. *Radiography* holds a most important place in the diagnosis of stone in the kidney and ureter—for stone in the ureter may cause all the symptoms of stone in the kidney, including localization and radiation of pain and even reflex anuria—and no radiographic examination for stone can be considered complete or satisfactory which does not include kidneys, ureters, and bladder. With the improvement in technique and in the experience of experts in interpreting radiograms the percentage of error is now very small. Yet even with the most perfect apparatus in the most expert hands stones escape detection radiographically in some cases. Among reasons for these failures are: the corpulence of the patient, the location, size and composition of the stone, and complications that may have arisen in and around the kidney. According to Braasch, the types of stone that may not be shown in the radiogram are: "(1) The soft secondary stone obscured by complicating pyonephrosis; (2) the small stone, the size of a grain of wheat or smaller, as seen with stone-forming kidneys or so-called oxaluria dolorosa; and (3) cystin and uric acid stones." By combining radiography with collargol injection of the renal pelvis (*pyelography*) it is usually possible to rule out errors which otherwise occasionally occur due to finding shadows on the plate simulating those of stone but of some other origin, such as calcareous deposits in tuberculous foci or cyst walls in the renal parenchyma, lymphatic glands or other structures, or from gallstones; though shadows from these latter, when present, are usually in the form of characteristic rings. The position of the ureter and its relation to any shadow along its course is also distinctly outlined; hence the use of this method tends to eliminate the danger of operating for renal or ureteral stone when none is present—a not infrequent occurrence in former times.

Further aids in diagnosis are: The evidence to be gained by cystoscopy, by employment of Kelly's method of catheterizing the ureters with the wax-tipped catheter, by the use of functional tests, especially phenolsulphonephthalein, and by the careful chemical and microscopical examination of the urine from each kidney. The evidence obtained by these procedures, by radiography, pyelography, and general physical examination, combined with the history, should result in a correct diagnosis in all but an extremely small percentage of the cases.

Nephrolithiasis must be differentiated from tuberculosis and tumors of the kidney, chronic hemorrhagic and other types of nephritis, from movable kidney, from hydro- and pyonephrosis of other origins, from appendicitis, gallstones, intestinal obstruction, and various other extrarenal conditions giving rise to one or more of the above symptoms; while it must not be forgotton that appendicitis, gallstones, or other abdominal lesions may occur coincidently.

Treatment.—This is prophylactic, palliative, or operative. Prophylactic treatment is indicated after the passage of a solitary calculus, when a patient habitually passes urine that is hyperacid and often

contains considerable amounts of calcium oxalate or uric acid crystals, or when a patient presents other evidences of predisposition to stone formation. It consists in exercise, a proper diet, and the drinking of sufficient water, with or without drugs, to cause a copious flow of slightly acid urine. Palliative treatment, directed to the relief of pain and avoidance or control of infection, is indicated when the presence of stone is suspected or discovered during the course of some other more serious illness, or when the stone is not causing appreciable damage to the kidney and for any reason the patient is a poor operative risk, or occasionally when the stone is so small and in such a situation that it may reasonably be expected to pass spontaneously under the influence of strong diuresis. Expectant treatment in the latter type of cases must be under strict supervision and operative methods advised at the first sign of injury or infection of kidney or ureter, or as soon as it becomes apparent that the stone is not likely to pass spontaneously.

When a stone is once formed there are no medicinal agents which will cause its solution *in situ*, though its further development may sometimes be temporarily held in abeyance. Sooner or later operation will usually be necessary and, as the result in non-intervention is generally serious impairment if not ultimate complete destruction of the kidney, procrastination is dangerous and usually unjustifiable. During the aseptic period the stone may be removed by pyelotomy, which is the operation of choice if conditions are favorable, or by nephrotomy. With mild degrees of pelvic infection pyelotomy may sometimes be performed though it is usually safer, even in the mild cases, to do a nephrotomy. The incision in the kidney may be made longitudinally a little posterior to the convex border, the usual method, or Marwedel's method of incision over the stone in a line radiating from the pelvis (transverse incision) may be employed. When there is marked infection and there has been considerable destruction of parenchyma, the decision between nephrotomy with drainage or nephrectomy is often one which requires the exercise of the nicest surgical judgment. When the kidney is clearly destroyed beyond hope of its being of any considerable value it should be removed at once (providing the other kidney is properly functionating) if the patient's condition will warrant that procedure, otherwise it is drained and may be removed later. Opinion is still divided as to which kidney to operate upon first when both are calculous, or whether it is best to operate upon both at the same sitting. The decision will often depend upon the result of functional tests, which should always be made in cases of this sort even if they are dispensed with in the simple, aseptic, unilateral type. When calculus on one side is blocking the ureter and pus and urine are collecting behind it, that kidney should certainly be operated upon first if the condition of the patient will not allow the bilateral operation. Persistent anuria demands *immediate* operation, which should be nephrotomy with or without decapsulation as circumstances direct. The possibility of calculus formation in a congenital solitary kidney must be borne in mind and forms another cogent reason for the routine employment of cystoscopy, ureteral catheterization and the phthalein functional test before undertaking an operation where the question of the removal of a kidney may come up. When calculus affects a congenital solitary kidney, or when the other kidney has already been removed or is known to be practically functionless, the treatment must be what Lilienthal[6] aptly calls "conservative surgery *de luxe*."

After a stone has been removed, the pelvis and calices should be explored for other stones or fragments. If a stone is broken in attempting its removal it should be reconstructed to see that all fragments have been recovered and the pelvis washed out with a strong current of saline to remove all small particles. It is often advisable to pass a catheter down the ureter to insure its being free from small stones or fragments. To make sure that all small calculi have been removed from the kidney, Squier[7] makes use of a portable *x*-ray apparatus and specially designed right-angled-vision fluoroscope to aid in their detection after the kidney has been exposed and brought out on the loin. The fluoroscope is covered with a sterile bag and suspended around the operators' neck or is held by an assistant. He finds that with the use of this apparatus the possibility of any calculus escaping detection is obviated.

Prognosis.—The prognosis in non-operated cases has already been sufficiently discussed. The operative mortality varies with the aseptic or septic conditions in the kidney, the time of operation, the degree of impairment of the kidneys, the general condition of the patient, and the type of operation that is necessary. In the early cases, where there is no infection, the patient is in good condition and pyelotomy or nephrotomy are easily performed, the operative risk is small—almost negligible. In the infected cases, in those with bilateral involvement, and especially in those requiring nephrectomy, there is a considerable mortality and the percentage increases rapidly in the more serious cases, reaching the highest point in bilateral calculous disease with bilateral infection.

Regarding recurrence, when a single aseptic stone has been removed at an early stage, and the patient then lives in accordance with reasonable hygienic and dietetic rules, other calculi rarely form unless the individual is one of those unfortunates who seem especially predisposed to calculus formation. When infection has already taken place there is more likelihood of subsequent calculous disease, not only in the operated but also in the unoperated kidney; yet even under these circumstances further stone formation is rather uncommon. Wesley Grove Vincent.

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Kidneys, Congestion of the.—Congestion or hyperemia of the kidneys may be acute or chronic, active or passive.

Active congestion of the kidneys is a condition of acute or active engorgement of the blood-vessels of the kidneys unassociated with exudation. In most cases it represents the earliest stage of acute nephritis, in other cases it is part and parcel of this disease, and inasmuch as it is extremely rare for acute congestion of the kidneys to exist without at least a slight amount of exudation, there can be no sharp dividing line between such acute congestion and acute nephritis. Indeed, the typical examples of "acute congestion" of the kidneys encountered after death are almost exclusively examples of acute Bright's disease. In a great majority of cases therefore the etiological factors of active congestion of the kidneys are the etiological factors of acute nephritis (*q.v.*). However, it is likely that in some cases congestion may exist alone—*e.g.* in conditions of mild toxemia such as occur in certain infectious diseases; in mild poisonings by certain drugs and chemicals, such as cantharides, copaiba, turpentine, arsenic, carbolic acid, etc.; after the use of certain stimulating diuretics; after the administration of ether for anes-

thesia, etc. It has been attributed also to sudden contraction of the blood-vessels of the periphery of the body following exposure to cold, and to loss of vasomotor control. It probably occurs also in conditions of increased functional activity, such as occurs in one kidney after extirpation of its fellow, and when one kidney has been rendered functionless by the blocking of its ureter with a calculus, etc. In acute congestion the kidney is enlarged, somewhat softened and deep red in color, or reddish brown and mottled. Its capsule strips readily and reveals distended and congested vessels, and on section the organ drips blood. The glomeruli are distended and the cells are the seat of a cloudy swelling.

In general, *symptoms* are wanting, at most they are indefinite. In cases with definite symptoms there is more or less disturbance of the renal epithelium, and the condition, except that it disappears with the removal of the cause, is scarcely to be distinguished from acute toxic or degenerative nephritis, or the mildest grades of acute diffuse nephritis.

Passive congestion (mechanical congestion) of the kidneys occurs most frequently in conditions of general venous stasis and less frequently in cases of more or less obstruction to the return circulation from the renal veins, such, for instance, as may result from pressure on the renal vein or veins by a tumor, aortic aneurysm, pregnant uterus, ascites, deformities of the vertebra (causing angulation of the renal vein), and in cases of thrombosis of the ascending vena cava and the renal vein or veins. In most cases it is associated with failing cardiac compensation due to valvular disease of the heart, fibroid heart, adherent pericardium, emphysema, interstitial pneumonitis, chronic adhesive pleuritis and mediastinitis, extensive tuberculosis of the lungs, etc. It occurs also in cases of cirrhosis of the liver.

The kidney, the seat of passive congestion (cyanotic induration, cardiac kidney), is enlarged, red, and much firmer than normally. The capsule strips readily and reveals distended veins, and usually a smooth surface that is dark red in color. The cut surface is moist and succulent and the glomeruli are prominent. The color is much darker than normally and has a bluish or a purplish tinge. This hyperemia, if long continued, leads to cyanotic induration, there occurs hyperplasia and subsequently contraction of the connective tissue. After this stage the kidney is smaller than before, the capsule strips less readily and the surface is slightly granular (the congested and contracted kidney). In reality this condition is a diffuse nephritis.

The *symptoms* are chiefly a diminution in the amount of urine—the daily quantity in some cases being less than 200 c.c. The urine is concentrated, dark in color and of a high specific gravity. It usually contains a small amount of albumin, the amount depending upon the functional activity of the heart and the degree of associated changes in the renal epithelium. The sediment usually contains a few hyaline casts. Complications such as nephritis, hemorrhagic infarction, etc., may change the urinary picture markedly. In uncomplicated passive congestion of the kidneys uremia is practically unknown.

The *diagnosis* of passive congestion of the kidneys usually is a matter of comparative ease. The symptoms of the primary condition generally predominate and the congestion of the kidney is readily recognized as part of a general venous congestion in failure of the circulation. The cyanosis and dropsy contrast strongly with the pallor and dropsy of Bright's disease. Further, the amount of urine voided daily, as well as the amount of albuminuria, varies from day to day with the functional activity of the heart. The urine then furnishes trustworthy evidence of the condition of the venous circulation. In some cases with marked venous congestion difficulty may be encountered in differentiating the condition from a condition primarily renal and secondarily cardiac.

The *prognosis* depends wholly upon the primary disorder and upon whether the lesions of diffuse nephritis have developed. Under proper treatment applied early in the disease, the kidney may be completely restored to normal. The advent of the renal condition, however, may increase the gravity of the prognosis of the primary condition.

The *treatment* is the treatment of the primary disorder. In most cases then it is the treatment of failing cardiac compensation. Shelter, warmth, rest, and good food are indispensable. Cardiac stimulants, alkaline diuretics and cathartics are the drugs used, the most important one of all being digitalis.

Aloysius O. J. Kelly.
Revised by Ralph G. Stillman.

Kidneys, Infarcts of the.—It has long been known that pathogenic microorganisms may gain access to the blood by absorption from the intestine, from furuncles, carbuncles, or other septic foci, and in the course of acute infectious diseases; that while some may pass through the kidney without causing appreciable damage, others produce varying degrees of parenchymatous nephritis, and still others may be arrested in their passage through the kidney, producing secondary septic foci in the form of septic infarcts of the renal cortex; and that this is sometimes followed by extension of the septic process into the perinephritic tissues and also throughout the kidney, thus producing pyelonephritis and ultimately resulting in pyonephrosis with the destruction of practically all secreting tissue. While sometimes bilateral, as would be expected, it was found that frequently the lesion was unilateral, this being explained by assuming a condition of diminished resistance in that kidney following previous injury or disease; and this hypothesis was borne out experimentally. Many such observations had been made by surgeons and pathologists in various parts of the world; but it is only in recent years, and due almost entirely to the pioneer work of Brewer, of New York, that the relative frequency and surgical importance of hematogenous infection resulting in acute, unilateral, septic infarction has been appreciated. It is, therefore, to his writings that one must turn for detailed reports of the experimental work and a comprehensive review of other data leading to the recognition of this condition as a clinical entity; while it is also his observations of a considerable number of clinical cases which furnish a logical foundation for the description of the manifold symptoms and appropriate treatment in cases of septic infarction of varying degrees of severity.

Septic infarcts in the renal cortex are due to the arrest of pathogenic bacteria alone or of minute bits of infected material. The organisms most frequently found are the colon bacillus, typhoid bacillus, staphylococci and streptococci; rarely the pneumococcus or *Bacillus pyocyaneus*. Over eighty per cent. of the cases have occurred in women; the right kidney has been involved much more frequently than the left; and cases have usually occurred during or following an acute infectious disease, or when there was a known septic focus elsewhere, or, occasionally, after simple abdominal operations. The pathologic conditions found in the clinical cases are identical with a large proportion of the results obtained in animals when broth cultures of various organisms were injected into the blood stream and one kidney was subjected to varying forms and degrees of trauma. Brewer found that in some cases where the organism was of great virulence lesions were produced in both kidneys, but those in the uninjured kidney were comparatively trivial and usually limited to more or less parenchymatous degeneration from the toxemia. His experiments showed that the lesions most com-

monly found in the injured kidney "are due to a plugging of the smaller arteries and capillary vessels with groups of organisms. These minute emboli are later surrounded by an encircling zone of round-cell infiltration. Where the larger trunks are thus involved, triangular infarcts are present; where the capillaries only are involved, minute abscesses are seen throughout the cortex and beneath the capsule. If the process is allowed to go on, the bacterial emboli are rarely recognized; only areas of necrosis and purulent infiltration are found. At a still later stage many of these collections of pus coalesce, forming large parenchymatous abscesses, which may rupture through the capsule and give rise to a perinephritis, or into the pelvis, giving the typical picture of pyelonephritis. In some of the cases the condition has been designated as an acute, purulent, interstitial nephritis." In his opinion all of these appearances are but different stages of the same process.

Symptoms.—Brewer recognizes three types of hematogenous infection: the hyperacute, or fulminating, the intermediate, and the mild. In the *fulminating* cases the toxemia is sometimes so overwhelming that the patient dies before symptoms characteristic of renal sepsis are detected. From a study of about twenty cases of this type Brewer summarizes the symptoms as follows: "The disease may or may not be ushered in by a chill. When present it generally indicates a severe type of infection. The initial rise of temperature is high, generally 104° or 105° F.; pulse frequently 120 or above. The toxemia is marked from the first and, with high fever, suggests often an acute grippe, lobar pneumonia, or one of the exanthemata. Then follows a more or less vague pain in abdomen or flank corresponding to the side of the lesion. Tenderness and muscular rigidity over the region of the appendix, or gall-bladder, lead often to error in believing one of these organs to be the seat of disease. As the urinary secretion from the affected kidney is greatly diminished, and is largely diluted by the abundant secretion from the unaffected organ, the mixed urine, when passed or drawn from the bladder is often quite normal in appearance, and the slight trace of albumin, blood, and pus is often overlooked unless a more than ordinarily careful examination is made. The one pathognomonic sign present in all cases is a marked unilateral costovertebral tenderness." Prostration is marked in these cases, there is often headache and vomiting, severe abdominal pain which may radiate and the patient seems desperately sick. Cystoscopic examination (if the patient is in condition to stand it) will show that there is little or no urine coming from the affected side; while if a specimen is obtained by ureteral catheterization, it will be highly albuminous and contain a variable number of blood and pus cells. Upon cutting down upon these kidneys the perinephritic tissues are found edematous, the kidney somewhat enlarged and congested, and the surface shows numerous elevated, deep red spots or groups of miliary abscesses; while on section there may be numerous suppurative and necrotic areas and one or more triangular infarcts.

The *intermediate* type, which includes the majority of cases, "often simulate in their early symptomatology, appendicitis, cholecystitis, or abscesses of the liver." There is, however, costovertebral tenderness and decreased urinary output from the affected side as shown by ureteral catheterization. In these cases the initial fever may be high but begins falling within forty-eight hours while there is less prostration and the pulse rate and quality are good. The pathological condition is similar to that of the previous type but of lesser degree; yet, if untreated, extensive destruction of parenchyma with abscess formation, pyelonephritis, and ultimate pyonephrosis may be the final outcome.

In the *mild* cases subacute appendicitis is sometimes simulated. Pain is seldom marked and may be entirely absent, the only signs being costovertebral tenderness and the presence of a small amount of albumin in the urine with perhaps a few red blood and pus cells. These cases sometimes account for the slight rise in temperature noted after abdominal operations, and if pus is found in the urine are usually diagnosed as mild pyelitis.

Treatment.—In the fulminating cases prompt nephrectomy apparently offers the only hope of cure. Brewer's latest report (1913) covers sixteen cases of this type, of which two with no treatment died; four with nephrotomy and drainage, all died; ten with early nephrectomy, all survived. In the intermediate cases, where the temperature begins to fall within forty-eight hours and there is coincident apparent improvement in the general condition, early decapsulation, with incision and drainage of any abscesses or necrotic areas found, will usually suffice; but in some cases secondary nephrectomy has been necessary. Hotchkiss has reported two cases of excision of the infarct and establishment of drainage. In both the infarction was limited to the upper pole, and both patients recovered. He also refers to the fact that Woolsey had also made use of this procedure. The treatment of the mild types may well be expectant and is summed up by Brewer in three words: "Rest, water, urotropin."

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Kidneys, Inflammation of the.—See *Nephritis*.

Kidneys, Injuries of the.—Injuries to the kidney are usually produced by blows, falls, or kicks, but may also occur when the lumbar region is crushed, as under the wheels of a wagon or between wagon and wall. Cases have also been reported where injury was caused by sudden change in posture or muscular strain. Usually but one kidney is injured, the right more often than the left, but both may be injured in severe crushing accidents or in falls from a considerable height. With most bilateral injuries, and not infrequently in unilateral cases, there are also injuries to other structures such as fractures of the lower ribs, injuries to the liver, spleen, intestines, etc. According to Watson[1] such complications occur in about twenty per cent. of the cases.

Injuries to the kidney occur with and without an external wound. Without an external wound leading to the kidney they are usually classified as subparietal or subcutaneous, although Lejars[2] and a few other writers consider all grades of injuries without external wound under the heading of contusions. Brewer[3] divides subparietal injuries into three grades: Simple contusion with or without injury to the capsule and subcapsular hemorrhage; incomplete rupture, in which the parenchyma is fractured but without opening of the pelvis; and complete rupture, in which the entire organ is torn across, freely opening the pelvic cavity. This is the most logical classification, not only on pathologico-anatomical grounds but also because the severity and number of the symptoms *usually* vary in approximately direct proportion to those three grades of injury, although, and I wish to strongly emphasize the fact, *this is by no means invariably true*. With subparietal injuries, a slightly lacerated kidney and the resulting hematoma are not primarily infected, unless a pre-existing septic focus has been opened into, and infection may never take place; but with the more severe grades of injury and especially in those communicating with a calyx or

splitting open the pelvis, allowing extravasation of urine, infection is very apt to occur sooner or later if the case is allowed to drift. The source of infection may be the urine or the adjacent intestine, especially after the nutrition of its wall has been more or less compromised by the pressure of extravasated urine or a large hematoma; or infection may come through the lymphatics, or there may be a hematogenous infection. The infecting organism most frequently found is the colon bacillus; among others, staphylo- and streptococci and the tubercle bacillus, the latter usually as part of a mixed infection.

With *contusion* of the kidney there may be simple subcapsular ecchymosis or a separation of a considerable portion of the unruptured capsule with the formation of a subcapsular hematoma; the fatty capsule may be torn, with or without fissures in the true capsule, and this, as a rule, is followed by slight or moderate bleeding, though occasionally a fairly large hematoma forms from this apparently insignificant source. Rarely, with fissure in the true capsule in the line of laceration of the fatty capsule there is extensive decapsulation of the kidney.

With *incomplete rupture*, where the parenchyma is fractured but without opening the pelvis, fissures of varying length and depth may be found and occasionally, as in a case of Peyrot's quoted by Lejars, a large portion of one pole may be nearly or quite separated from the rest of the kidney. The amount of hemorrhage in these cases is variable, depending upon the direction and degree of laceration of the parenchyma. Usually the fracture lines are transverse to the long axis of the kidney and parallel to the course of the blood-vessels, in which case hemorrhage is moderate in amount unless the fractures are deep or unusually numerous; but in some cases the fractures are stellate or across the line of blood supply and then hemorrhage is apt to be severe and accompanied by the rapid development of a large perirenal hematoma. In these also there is much less tendency to spontaneous cessation of the bleeding. This was shown particularly well in Peyrot's case where he found profuse active hemorrhage upon operation about six weeks after the accident.

Complete rupture includes all cases where there is a fracture through the parenchyma into the pelvis. In these the degree of injury varies from a single transverse fracture to almost complete pulpifaction of the kidney. With complete rupture hemorrhage is usually profuse and this is necessarily accompanied by extravasation of urine into the perirenal tissues. In this and the preceding type of injury a tumor is usually demonstrable in the loin, while extravasation may also take place into the peritoneal cavity, especially in children, where the peritoneum is very thin. This may occur from rupture of that membrane at the time of the accident or as the result of pressure from extravasated blood and urine. In these two types also secondary infection is a frequent occurrence, especially when there is urinary extravasation. Rarely, the pelvis alone has been ruptured, the ureter torn across or, without injury to the kidney itself, one or more of the vessels of the pedicle have been torn, usually a vein.

Symptoms.—As a rule, these vary roughly in direct proportion to the extent of injury and include immediate shock and collapse, hematuria, progressive anemia, and other evidences of internal hemorrhage, pain or tenderness followed by gradually increasing tumor in the loin, and rise of temperature which is accentuated later if infection takes place. If the peritoneal cavity is invaded by extravasate, or with coincident injury to liver, spleen, intestine, or other intraabdominal organs, peritonitis and other symptoms referable to such injured organs also appear. Occasionally, without actual intraperitoneal injury, symptoms suggestive of peritonitis occur such as nausea, vomiting and moderate tympanites, caused by pressure upon or other interference with the adjacent colon. With simple contusion there may be evanescent slight shock with slight hematuria and pain or tenderness in the loin, both of which disappear in the course of a few days. With the more severe injuries we find individual variations in the symptoms as follows:

Shock is very profound and often accompanied by marked symptoms of collapse in the severe types of injury. In these, shock usually appears at once but is occasionally slight or absent at first and develops rapidly later, especially when there is marked internal hemorrhage.

Hematuria is a very constant symptom, usually appearing within the first few hours, though its appearance with slight injuries may be much delayed. The quantity of blood in the urine is very variable and *must not* be taken as an index of the degree of injury; for with the most severe injuries, where the kidney is completely disorganized, hematuria may be absent or very slight in amount and soon cease altogether, although an enormous hematoma may be forming in the loin or within the peritoneal cavity. At other times there is a profuse hematuria which suddenly ceases, due to blocking of the ureter with clots. After symptoms of renal colic the clot may pass to the bladder and the flow of bloody urine be reëstablished. Rarely the flow of blood down the ureter is so rapid and excessive that the bladder becomes filled with clot which cannot be washed out by ordinary means and may require the Bigelow evacuator or a suprapubic cystotomy for its removal. That the hematuria is not due to rupture of the bladder is shown without cystoscopy by first emptying the bladder and then injecting a measured amount of sterile fluid, the same amount being immediately returned through the catheter.

Pain or tenderness in the loin is usually well marked in the more serious injuries and gradually increases in severity as hematoma develops and when infection supervenes. In the latter case the pain is often throbbing in character. With any considerable extravasation a tumor may be felt in the loin which may give fluctuation.

Elevation of temperature may at first be moderate and due to blood absorption, but with the advent of infection there is a sharp rise, the pulse rate markedly increases and there may be chills and other evidences of sepsis.

Diagnosis.—This rests upon a consideration of the history, the presence of one or more of the above symptoms, cystoscopic examination with or without catheterization of the ureters and, occasionally at least, the evidence furnished by the *x*-ray. In typical cases with history of a blow or fall, some degree of shock, tenderness in the loin, and the presence of blood in the urine, diagnosis is easy. Difficulty is encountered most often in the very mild and some of the very severe cases. When shock is profound, an accurate history unobtainable, there is no hematuria, cystoscopy inadvisable because of the patient's condition, while there is a question as to injury of other viscera, it may be impossible to make a positive diagnosis until a tumor can be felt in the loin together with evidence of internal hemorrhage which, with the non-development of focal symptoms elsewhere, makes the diagnosis of severe injury to the kidney apparent. The efficacy of pyelography in determining the presence and amount of kidney injury has been pointed out recently by Luckett and Friedman.[4] This resource, employed in two cases by Luckett and in one by Friedman, was of great service in showing the necessity of early operation in Luckett's cases and the advisability of non-interference in that of Friedman.

Treatment.—This is *expectant* or *operative*. Expectant treatment comprises proper medical treatment of the initial shock, absolute rest secured by

morphine if necessary, the administration of urinary antiseptics, the application of the ice-bag, and the employment of any other non-operative measures that seem advisable. It is indicated in cases of apparent contusion with little or no shock, little if any hematuria and no evidence of the formation of a perirenal hematoma. It is also usually indicated while shock is profound and as long as there is any element of doubt as to the nature and approximate extent of the injury. Expectant treatment *may* be continued after recovery from the initial shock and when the symptoms point to a moderate amount of

Fig. 3597.—Pyelography in the Diagnosis of Kidney Injury. Complete laceration of lower pole (about one-fourth) of right kidney in one of Dr Luckett's cases. (Luckett and Friedman, *Annals of Surgery*, December, 1914.)

laceration of the kidney, even with the presence of a hematoma, as long as there is no indication of infection or excessive hemorrhage and the general condition of the patient is satisfactory. Expectant treatment under these conditions, however, is fraught with danger. It is well known that the symptoms sometimes fail to correspond for a time with the seriousness of the lesion and the patient suddenly passes from a condition of apparent safety to one of extreme hazard. The bleeding into the perirenal tissues may soon cease spontaneously or may continue for weeks, as in Peyrot's case referred to above; while infection is an ever-present possibility. It is impossible to formulate an arbitrary rule by which one may recognize the time when expectant should give way to operative treatment. This is a matter for decision in the individual case and requires the exercise of good surgical judgment. Most experienced surgeons counsel exploratory operation as soon as it seems apparent that the injury is more than simple contusion. In such cases Lejars says: "The best plan, in my opinion, is to operate as soon as possible, to open up the focus of injury, stop any bleeding, and so prevent the development of septic complications." This decision was forced upon him by encountering cases where dangerous complications developed insidiously during expectant treatment. Woolsey,[5] on the other hand, is inclined to treat cases expectantly unless he strongly suspects a severe rupture, and provided there exist no infection of the urethra or bladder; yet he takes pains to make it clear that he believes early operation essential when there *is* a severe rupture. As already pointed out, the symptoms cannot always be relied upon as an index of the extent of damage, and when mass is present early operation, even in cases of apparently moderate severity, surely affords the best guarantee of speedy and uncomplicated recovery. In most statistics the mortality with expectant treatment considerably exceeds that where operation has been performed; and this in spite of the fact that the operative percentage has doubtless been inordinately increased because many operations have been undertaken too late, and part of the operative mortality is thus really chargeable to "expectant" procrastination. Lardennois[6] in an exhaustive study of contusions, lacerations and ruptures of the kidney, found the average mortality with early operation to be about ten per cent., while expectant treatment, with or without secondary operation, gave a mortality of about twenty-five per cent. With present-day aids to early and accurate diagnosis and with improved operative technique the mortality with early operation is certainly less than during the period covered by Lardennois' statistics or those of Watson in this country.

Exploration of the kidney should usually be by the lumbar route. When intraabdominal lesions are also present anterior incision will of course be necessary, but even in these cases retroperitoneal drainage through the loin should be provided. For the lumbar operation the Mayo type of incision should be used and should be sufficiently generous to afford the best possible access to the kidney and its pedicle as soon as the perirenal tissues are incised. At this point one must be prepared to encounter almost anything in the way of hemorrhage from a harmless mixture of dark fluid blood, urine and clots to a continued gush of bright red blood. Bleeding is controlled as soon as possible, clots removed and the cavity sponged out, then the extent of damage to the kidney is determined. The kidney should be treated as conservatively as possible. Unless too extensive morcellation has occurred it is usually possible to reunite the fissured parenchyma and to control the hemorrhage by suture, by packing, or by a combination of the two. Sutures should be reinforced by packing in all cases where there is any danger of further bleeding of any consequence. If one pole has been partially, or even completely, separated from the kidney, and the patient's condition is good, it is justifiable to attempt its preservation if that portion of the kidney can be brought up sufficiently to allow accurate suturing; otherwise it is removed, through-and-through sutures passed to control the hemorrhage, or the hemorrhage is controlled by packing as was done in Luckett's case herein illustrated. Nephrectomy is reserved for those cases where the kidney is injured beyond hope of repair, where the blood supply seems likely to be inadequate, where the pelvis or ureter are irreparably injured, and when the condition of the patient will not allow time for the practice of conservative surgery. In most subparietal cases where there has been a hematoma of any considerable extent and in *all* cases accompanied by an external wound or where there has been extravasation of urine, free drainage must be provided.

Wounds of the Kidney.—These are usually gunshot or stab injuries, though they may result from railroad or factory accidents or from numerous other causes. All grades of injury are met with depending upon the character of the etiological factor and the force with which it acts. In these cases other viscera are very apt to be involved, especially in the case of gunshot wounds, while the same holds true in regard to stab wounds except those which are inflicted through the loin. The symptoms may be slight, as in cases where stab in the loin has merely nicked the cortex, and consist of slight bleeding through the external wound with or without hematuria; or, with

severe injury, there may be profuse hemorrhage through the wound, marked hematuria, shock, and evidences of internal hemorrhage. Hematuria is the principal diagnostic sign, for unless the wound in the loin is large it is often impossible to know whether the blood appearing externally is coming from the kidney or not. Hematuria may also be the only symptom pointing definitely to the kidney when there are concomitant injuries of other viscera.

Treatment in the apparently slight wounds may properly consist in the introduction of drainage, making sure that it reaches to the bottom of the wound, and instituting expectant treatment along the lines already described. Meanwhile the urine, pulse, temperature, condition of the wound and the general condition of the patient will be watched and operation performed at the first evidence of sepsis or other complications. It should be stated, however, that some surgeons believe in immediate exploration when convinced that the kidney has received any wound whatever. When it is evident that the kidney has been severely wounded operation should be performed as soon as possible, usually disregarding the primary wound and using the usual lumbar incision in order to have sufficient room to handle whatever conditions may be found. This incision may often be closed after treating the injuries in accordance with the rules previously given, the primary wound being used for drainage. It is of course understood that the presence of lesions elsewhere may influence the decision as to what should be the proper handling of the kidney injury in an individual case. (See article on *Gunshot Wounds*).

WESLEY GROVE VINCENT.

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Kidneys, Movable.—*Synonyms:* Ren mobilis, Nephroptosis, Loose Kidney, Floating Kidney.

While the terms floating and movable kidney are often used interchangeably, floating kidney in the strict sense is a congenital abnormality in which the peritoneal reflection around the kidney and its pedicle is as complete, or nearly as complete, as in the case of the small intestine, and there is thus formed a mesonephron. Under these circumstances the kidney moves within the peritoneal cavity and there may be extreme degrees of mobility, the kidney sometimes reaching the true pelvis and being easily pushed over beyond the median line. These kidneys may never give symptoms sufficient to call attention to the condition and may be discovered quite by accident. This type is so rare that many operators of wide experience do not hesitate to admit that they have never encountered this anomaly.

Movable, or loose, kidney has normal or nearly normal peritoneal reflections in the majority of instances and in its descent passes down behind the peritoneum, burrowing its way through the post-peritoneal fat and pushing the peritoneum away from the posterior abdominal wall, thus forming a pouch in which it usually slides up and down with each respiratory cycle when the patient is in the recumbent position, and to the bottom of which it falls when the patient assumes a more erect position. Three degrees of mobility are usually described: In mobility to the first degree the lower pole can be felt—*palpable kidney;* in the second degree the upper pole can be felt—*movable kidney;* while descent to the third degree has been considered to exist when the kidney drops below the navel, and to this the term *floating kidney* has often been applied, although etiologically and clinically there is no reason why the level of the navel should be arbitrarily chosen for a change in nomenclature. The term *displaced kidney* is usually applied to a kidney which is fixed in an abnormal position. This may be a congenital anomaly, or a previously movable kidney may have become adherent at some point in its acquired range of descent.

INCIDENCE.—Movable kidney may be found at any age, but most frequently between 20 and 45. The right kidney is affected much more often than the left, the proportion being about 12 or 15 to 1. The frequency of movable kidney in women has been estimated by Edebohls, and by Lindner and Küttner at 20 per cent.; by Glénard at 22 per cent.; by H. Morris at 7 to 10 per cent.; and by various other authors from as low as 4 to 56 per cent., as estimated by Harris. It has been considered about four or five times as frequent in women as in men, but this ratio is probably too high.

ETIOLOGY.—The kidney is supported by its vessels; by its fatty capsule, around which there is a well-defined fibrous layer variously designated as the lamina fibrosa, fascia renalis or perirenal fascia, which sends numerous fibrous bands through the fatty tissue to form a loose union with the true capsule; by the peritoneum which passes in front of it; by intra-abdominal pressure; and by the more or less deep shelf upon which it rests. The fact that congenital body conformation has much to do with the retention of the kidney in its normal situation has long been recognized, and much stress was laid upon this point by M. L. Harris in 1901; but Goldthwait of Boston and Coffey of Portland, Oregon, have been perhaps foremost among those who have emphasized this point in recent years. The normal kidney does not hang suspended by the above mentioned attachments, but rests upon an inclined plane formed by the jutting forward of the muscular tissues following the curve of the spine at that point and by the psoas muscle as it passes from its spinal attachment to the iliac fossa. Coffey,[1] in a widely quoted and elaborate study of ptosis of the abdominal viscera, showed that in a normal man this supporting plane or shelf is about four inches wide; and the funnel shape of the kidney region was well shown by the fact that the area of a cross-section of the abdomen at the level of the lower pole of the kidney was forty-four square inches, while at the level of the base of the appendix it was but fourteen square inches. In women this space is regularly much shallower. But while the depth of the renal fossa and the supporting elements mentioned above may be normal. Coffey, finds that there is another condition which also contributes largely to the stability or instability of the kidney, namely, the degree of rotation and the lines of peritoneal fixation of the cecum. He states that anatomists have found that in one case of every five human anatomical subjects, the ascending colon has not properly fused with the parietal peritoneum, and the cecum and ascending colon hang by a mesentery. Thus when the colon has not rotated over beyond the edge of the kidney in the normal way, the kidney does not have the support of the ascending mesocolon but lies behind a single layer of the peritoneum, and Longyear is quoted for the statement that in these cases the colon seems to have a quite firm attachment to the lower pole of the kidney. Coffey believes that a unilateral movable right kidney is almost never seen except in cases where there has been a deficient peritoneal fusion of the ascending colon and mesocolon with the parietal peritoneum in front of the kidney. He further states that in a considerable portion of cases the descending colon has also failed to fuse; but incomplete fusion is not so serious on the left side, owing to the costocolic and gastrosplenic

ligaments, which form two very firm additional supports and thus prevent the descending colon from prolapsing and dragging the left kidney down with it. Consequently he finds that a floating left kidney is the one positive symptom which identifies a case of general ptosis, as the left kidney practically never goes down alone and never until the splenic flexure falls, and the splenic flexure practically never does fall until the fat in the kidney region has been absorbed. He therefore concludes that in a normal individual there is not the slightest tendency toward prolapse of the kidney. It is hardly to be expected that his so radical conclusions will be generally accepted, and still it is curious to note that twenty years ago Edebohls, working entirely from the clinical standpoint, concluded that movable kidney was present in twenty per cent. of all women, exactly the same percentage that Coffey cites as the anatomists' report of improper fusion of the cecum and ascending colon with the parietal peritoneum. While there can be no question that a very large proportion of movable kidneys are accompanied by more or less prolapse of other viscera, it is equally sure that there are numerous cases where the kidney has been the only prolapsed organ and where, from a clinical point of view, the movable kidney has been the primary seat of trouble.

Aside from those cases depending upon the anatomical considerations already referred to, and those where there is a general relaxed condition of the peritoneal attachments, movable kidney may be caused by wasting diseases which result in the rapid absorption of a considerable portion of the perirenal fat; by multiple pregnancies and by the removal of ascitic fluid or large tumors, causing a relaxation of the abdominal wall; tight lacing in which the pressure is applied at the lower thoracic zone, crowding the abdominal organs downward; prolonged coughing such as occurs in pulmonary tuberculosis or chronic bronchitis; and by continued slight trauma, as in skipping rope; while, in rare instances, severe acute trauma such as a fall or blow over the kidney region has been assigned as a cause, although it is more likely that mobility of the kidney was already present and the trauma merely served to accentuate or call attention to the condition.

Symptoms.—In the vast majority of cases there are no symptoms sufficiently distinctive to call attention to the kidney, and its mobility is discovered accidentally or in the course of general abdominal examination. Edebohls found definite symptoms referable to the kidney in only twenty per cent. of the cases where there was mobility, or four per cent. of all women examined; and this estimate is probably still approximately correct, though possibly too low. One fact that should be strongly emphasized at the outset is that *the intensity of the symptoms may bear but little relation to the degree of mobility*, symptoms of all gradations being found in some of the cases where the kidneys are merely palpable as well as in nephroptosis of greater degrees. The usual symptoms are: pain in the kidney region, nervous and digestive disturbances, including chronic constipation and, as particularly emphasized by Edebohls, chronic appendicitis. The pain varies from a sense of discomfort, a dragging or dull ache in the loin, to acute attacks simulating true renal colic. Often there is epigastric pain referred to a point somewhat to the left of the median line. The renal pain may remain localized or radiate in various directions, particularly down the ureter or in accordance with the distribution of the ilio-hypogastric nerve. Sometimes there are attacks of agonizing pain, often with nausea, vomiting, chills, and fever, and attended with marked prostration—Dietl's crises. These result from a twist or traction of the renal nerves and vessels, from torsion or sharp angulation of the ureter, or from a combination of these conditions. With these there may be marked congestion of the kidney and temporary hydronephrosis, and the enlarged and exquisitely tender kidney may be easily felt. These crises may follow traumatism, a sudden change in position, or may have no assignable exciting cause. During the attack there may be anuria but after the kidney has resumed its usual position, either spontaneously or through proper manipulation, the relief of pain may be almost instantaneous, while if the attack has existed for some hours or days reposition is usually followed by a copious flow of urine which at first contains albumin and casts, while blood is always present in microscopic or even macroscopic amounts. All pain except that of Dietl's crises usually disappears upon lying down, although some pain may persist if the patient lies upon the left side. The nervous symptoms are often marked and may be much in evidence with the lesser degrees of mobility. One of the most common of these reflex symptoms is palpitation and these attacks, in connection with the generally excitable state of the individual, may be particularly distressing. There may be marked neurasthenia with hysteria, while rarely there is melancholia. The gastric symptoms are those comprised by the term nervous dyspepsia, the tendency to eructations of gas being especially marked; but any one or more of the whole gamut of functional disturbances may be brought into play. The bowels are usually constipated, but there may be alternating attacks of diarrhea and constipation, or their action may be perfectly normal. Chronic appendicitis, due to interference with the appendicular blood supply by pressure of the kidney upon the superior mesenteric vessels, has been called by Edebohls the chief symptom of movable right kidney; for he found this condition present in eighty to ninety per cent. of all women having symptom-producing mobility of this organ. The remarkable frequency of at least coincident involvement of the appendix has since been confirmed by many observers; while the comparative frequency of associated lesions of the right tube and ovary has also been noted. Among other symptoms are: jaundice, intermittent hydronephrosis, hematuria, polyuria, and painful and frequent micturition. As a rule the average quantity of urine passed each 24 hours is rather less than normal and often contains a faint trace of albumin, numerous mucous cylindroids, and almost invariably a few red blood cells. Finally, it is to be noted that many of the symptoms are intensified during the menstrual periods and also that many of these symptoms are common to other conditions affecting the urinary, digestive, or genital tracts, so that careful differentiation is often necessary; while it must not be forgotten that frequently movable kidney and lesions affecting one or another of these tracts may coexist.

Diagnosis.—As most of the cases occur in fairly thin, long-waisted individuals, it is usually easy to detect abnormal mobility of the kidney by palpation. This is performed with the patient in the recumbent position and with the knees drawn up so as to relax the abdominal muscles. It is also an advantage to have the examining table slightly tilted, or hard pillows placed under the shoulders, so that the patient's back is slightly inclined from above downward. By this means slight degrees of mobility may be recognized which would perhaps otherwise escape detection, owing to the fact that the kidney tends to remain in its fossa when the patient is lying on a level surface. To feel the right kidney the examiner stands on the right side of the patient, his left hand brings the kidney forward by firm pressure in the loin between the last rib and the crest of the ilium, the right hand resting lightly upon the upper part of the abdomen just external to the rectus muscle, while the patient inspires deeply. The right

hand is then *gently* pressed upward and inward under the edge of the liver and during expiration the kidney may be felt to glide upward to its fossa, or remains imprisoned between the two hands. I would especially emphasize the necessity for gentleness in palpating, as thus not only is reflex muscular contraction avoided but the delicacy of the sense of touch is not interfered with by compression anemia affecting the nerve endings at the finger tips. In some instances the thumb of the left hand may be used for the anterior palpation, the right hand being pressed deeply into the abdomen at or below the level of the navel at the moment of expiration (Glénard's method), or both kidneys may be palpated simultaneously by pressure of the fingers in the loin posteriorly and the thumbs anteriorly at the moment of expiration. Palpation may also be performed with the patient sitting and leaning forward over the edge of the table, or standing with the weight resting on the leg of the sound side, the other leg being flexed and resting on a footstool. Mobility may also be determined by means of the *x*-ray, particularly when the renal pelvis has been injected with collargol. This procedure is especially valuable when there is reason to suspect any complication affecting the kidney or ureter, and occasionally in differentiating from extrarenal lesions.

Movable kidney must be distinguished from other diseases affecting the kidney and ureter, from a distended gall-bladder or abnormal lobe of the liver, from tumors of the mesentery, pylorus, or other structures of that region, and from ovarian cysts with a long pedicle. Among the aids to differentiation from other lesions is the fact that the kidney can usually be replaced in the loin and that there is a slight pain or sickening sensation upon light compression of the kidney.

Treatment.—This may be palliative or operative. Palliative methods consist in rest in bed for a long period, combined with attempts to improve the nutrition and increase the amount of perirenal fat as advised by S. Weir Mitchell; or the wearing of some form of mechanical support. The rest cure is seldom feasible and practically never entirely successful, though there may be temporary symptomatic relief. Pads making pressure upon or near the kidney are to be condemned. Many cases are, however, permanently relieved by wearing a belt or corset which makes firm pressure over the pubes and lower portion of the abdomen while the upper portion is uncompressed. The corset devised by Gallant fulfils these indications but an ordinary "straight front" corset, one or two sizes too small and fitted with two laces, so that the lower part may remain tight while the upper part is allowed to flare, gives satisfactory results. The patient should apply the corset while lying down and with the hips elevated, and it should be fastened from below upward.

When the symptoms are not relieved by palliative methods, nephropexy, perhaps combined with other operations on the genital or gastrointestinal tract, is indicated. Nephrectomy for this condition is absolutely unwarranted. The principal indications for operation are: constant pain in the kidney region, Dietl's crises, beginning hydronephrosis, and nervous and digestive symptoms without other demonstrable cause. Degree of mobility, *per se*, should not be considered an indication for operation for reasons already pointed out. One further point which should be emphasized, and to which I have already called attention elsewhere[2] is that inasmuch as chronic passive congestion is often followed by a more or less severe chronic nephritis, it is important that a movable kidney be anchored, even if otherwise giving no symptoms, if the urine continually shows evidences of renal congestion. The most frequent additional operation that will be necessary in cases of nephroptosis is appendectomy, which may occasionally be performed through the lumbar incision, but it is usually better to make a supplementary anterior incision. Some believe that fixation of the cecum is also usually required, and Wilms, Coffey, Duval, and others have devised operations to this end.

Technique of Operation. Since Hahn, in 1881, performed the first nephropexy, almost innumerable methods of performing this operation have been devised (Luzoir[3]). The technique, at first very crude, has been gradually perfected, so that now there are several good methods available by which the kidney may be securely anchored. Most of these agree in principle with, and are useless modifications of, the last method devised by Edebohls[4] which is thus entitled to be considered the standard operation in this field. Edebohls' technique for nephropexy is essentially as follows: The patient lies prone with an air-cushion (Fig. 3598) under the abdomen, unless a table with special appliance for kidney work is used, the cushion being inflated to such a degree that the patient's back is horizontal. If my cushion is used, the lower compartment is inflated sufficiently to bring the patient to the proper position, then if the upper compartment be *slightly* inflated the corners pout up at each side and the patient is held absolutely securely. An oblique incision is then made along the outer border of the erector spinæ, from the lower

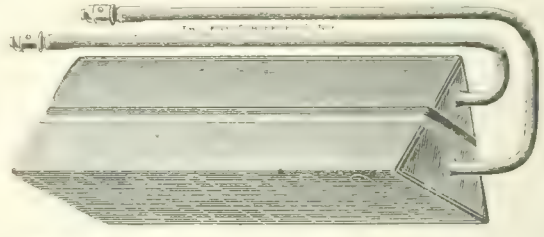

Fig. 3598.—Vincent's Kidney Cushion (*Medical Record*, December 6, 1913.)

border of the last rib to the crest of the ilium. Keeping close to the edge of this muscle, the incision is carried through the lumbar aponeurosis, or the fibers of the latissimus dorsi are bluntly separated, and the transversalis fascia incised exposing the perirenal fat. Avoid injuring the iliohypogastric nerve which follows, or sometimes crosses, the line of this incision. Incise the perirenal fat and deliver the kidney, with its fatty capsule, onto the back, (providing the kidney is sufficiently movable to allow this to be done without undue tension on pedicle or anomalous renal vessels) then dissect off and remove the fatty capsule. Incise the true capsule, on a grooved director, along the convex border and half way down both poles of the kidney. Strip back the capsule to a point about half way between the convex border and hilus. Pass four fixation sutures of forty-day chromic catgut through both the reflected and still attached portions of the capsule close to their line of junction, without penetrating kidney parenchyma. Two of these are placed on each side of the kidney, one at the middle of its upper and one at the middle of its lower half. (Fig. 3599.) Each of these sutures should be about fifteen inches long, the ends of each suture being clamped for identification as soon as passed. The kidney is now replaced and the sheath of the quadratus lumborum muscle opened from rib to ilium, *for it is to this muscle and not to fascia that the kidney is anchored.* The fixation sutures are now rethreaded and passed, skipping the anterior sheath but going through muscle and posterior sheath of the

quadratus lumborum and the erector spinæ internally, through the transversalis fascia and latissimus dorsi externally, the highest sutures emerging just below the last rib. After the incision, except the skin, has been closed with chromic catgut, the slack in the fixation sutures is gently taken up and these sutures, first the upper then the lower pairs, are tied and the ends cut short. The skin is then sutured with plain catgut, without drainage, and dressings applied. With proper technique, and if the patient is kept on the back for the next three

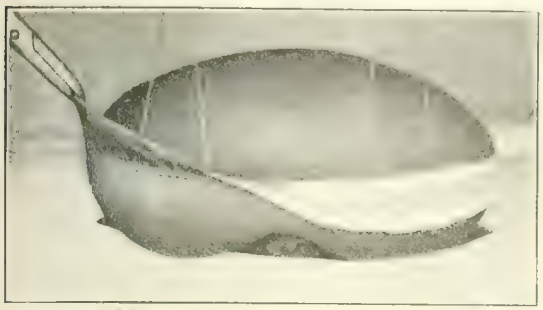

FIG. 3599.—Suspension Sutures in Nephropexy, passed through the reflected layers of the capsule without involving the kidney substance. The two companion sutures on the other side of the kidney are not shown. (Edebohls, *Annals of Surgery.*)

weeks, the kidney will practically always stay firmly anchored. The old-fashioned method of packing or suturing gauze under the lower pole of the kidney is not only unnecessary but absolutely unwarranted. It leaves an open granulating wound liable to infection, besides subjecting the patient to needless pain and prolonging the period of convalescence. The mortality from nephropexy is about 1 per cent.

Results.—The ultimate results after nephropexy are generally good. The failures are usually due to incomplete surgery; and that this is especially true when nephroptosis is accompanied by gastroptosis has been abundantly proven by Rovsing's brilliant results following radical surgery of all organs involved in this class of cases, when others, content with half-way measures, have failed. WESLEY GROVE VINCENT.

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Kidneys, Tuberculosis of.—While calculous disease of the kidney has been recognized since long before the beginning of the Christian era, renal tuberculosis was not recognized at all until about a century and a half ago, was very imperfectly understood even thirty years ago, and many problems, such as the avenues of infection and best methods of treatment under varying conditions, are still sources of almost endless discussion. According to Kelly and Burnam[1] the first recorded case was reported in 1767 by Morgagni who, while doing an autopsy, "found that the left kidney was tuberculous through an extension of the process from a large mass of contiguous lymph glands." The same authors state that Peters, who published the report of his case in 1872, performed the first deliberate nephrectomy for renal tuberculosis; that Babés in 1883, first demonstrated tubercle bacilli in the urine of a patient having renal tuberculosis, and that Steinthal (1885) was the first to upset the view that renal tuberculosis was but the end stage of a tuberculosis of the entire urinary tract. "In a series of twenty-four autopsies upon patients suffering with genitourinary tuberculosis he found the kidney involved in every case; the lower tract in only fifty per cent. of the cases; while in nine instances the kidney alone was involved." Before this, autopsies had shown that in about one-half of the cases one kidney alone was involved, hence the indication for nephrectomy was established. First the more venturesome, but soon also the more conservative surgeons began doing nephrectomy for renal tuberculosis; and the study of the specimens thus obtained, showing the early as well as the late pathology, together with the development of cystoscopy with ureteral catheterization and animal experimentation, have led to the present conception of tuberculous processes in the kidney. From this we have found that renal tuberculosis may be unilateral or bilateral; that there are two distinct types, acute miliary and chronic caseocavernous; and that the kidney is almost invariably the primary focus in the urinary tract from which the ureters and bladder are infected secondarily.

While it is within the bounds of possibility for tuberculosis to be primary in the kidney and a scant half-dozen such cases, as apparently shown by autopsy findings, have been reported, for all practical purposes renal tuberculosis, regarded from the standpoint of pathology, may be considered as always secondary to tuberculous infection elsewhere in the body. In the living patient, however, no other focus may be discoverable hence, from the clinical point of view, we are justified in speaking of renal tuberculosis as often being primary in the kidney, and of the manifestations in the ureter and bladder as being secondary to that as the primary focus.

Renal tuberculosis occurs at all ages but is most common in children and between the ages of twenty and forty. Broadly speaking, it is three times as common in children as in adults. Males are affected much more often than females, the proportion in various statistics ranging as high as 3 : 1; though this is certainly far beyond the absolute average. Kelly and Burnam consider involvement of the genito-urinary system as a whole to be as frequent in women as in men.

Since tuberculosis is such a widespread disease, it is not surprising that most statistics covering a thousand or more consecutive autopsies in a general hospital service show tuberculous foci in adult kidneys in from four to six per cent. of the cases, the average being about five; while in various series of cases coming to autopsy with *active* tuberculous processes elsewhere in the body the percentage of kidney involvement has been found to range between twelve and fifty, the immediate cause of death again being disregarded. In long-standing cases dying of pulmonary tuberculosis the percentage of renal involvement is usually very high. Murphy[2] states that renal tuberculosis occurs in five to ten per cent. of all early cases and in practically all advanced cases. Barthez and Rilliet (quoted by Kelly and Burnam) found that in children the percentage of renal involvement was about fifteen in deaths from all causes, and sixty-eight per cent. with active tuberculosis elsewhere. In both children and adults suffering from acute general miliary tuberculosis the kidneys are practically always involved and, with very rare exceptions, both are affected. In the chronic caseating type the infection is usually if not always originally unilateral; but it becomes bilateral in from ten to forty per cent. of the cases by the time they come to operation, and usually in more than fifty per cent. of the cases coming to autopsy. Macklem[3] finds that tuberculosis occurs in the kidneys as frequently as in all other genito-urinary organs combined. It occurs in the right kidney more often than the left. While it is thus seen that renal tuberculosis is an extremely common affection, tuberculosis affecting horseshoe kidney is exceedingly rare. Thévenot[4] reports one case and could collect but ten others from the literature.

Avenues of Infection.—Four routes by which the tubercle bacilli may reach the kidney have been suggested: (1) By direct invasion from tuberculosis of contiguous structures; (2) as an ascending infection through the ureter from a tuberculous focus in the lower genito-urinary tract; (3) through the lymphatics; and (4) through the blood.

Infection by Direct Invasion.—Though the capsule of the kidney usually forms a very efficient barrier to the extension of a tuberculous process originating either within or without the kidney, cases of undoubted authenticity have been reported in which the kidney has been involved by direct extension from a pre-existing focus in the adrenals, lymph glands, spine, and other contiguous structures. It must, therefore, be admitted, that in rare cases the kidney may be involved by contiguity.

Ascending Infection through the Ureter.—Previous to Steinthal's report (1885) this was considered the avenue of infection in practically all cases and, indeed, it was not until long afterward that any considerable proportion of observers would admit that this was the unusual rather than the common route. During the past fifteen years opinion has rapidly swung away from the ascending theory and to such an extent that now some insist that ascending infection through the ureter never occurs. H. Kümmell[5] voices current opinion regarding urogenital tuberculosis when he says: "We know that the kidney is the primary site of tuberculous infection of the urinary tract, and that from this focus infection gradually extends to the ureter and bladder." Most surgeons, however, admit the possibility of ascending infection and there are occasionally cases which seem to prove such an origin. Murphy states that in some cases the infection is an ascending one by way of the ureter from the bladder, prostate, seminal vesicles, epididymis, or testis; yet Kelly and many others hold that when renal and epididymal tuberculosis occur together they are independent affections. Brewer admits ascending infection but states that it is rare. Tracy[6] thinks that the kidney seldom becomes involved from the infection extending upward, but that this may occur if the lower end of the ureter be infiltrated and allow the urine to regurgitate. Lévy-Weissman[7] considers that reflux occurs because of the irritability of the bladder and the fact that as the bladder contracts violently the sphincter at its neck also contracts and thus the urine is forced up the ureter. This may account for ascending infection of the second kidney after the ureter on the originally infected side has become strictured or occluded. Marogna,[8] from a study based on material from the Institute of Surgical Pathology at Pisa, concludes that ascending infection is possible but very rare. An apparently good example of ascending tuberculous infection of the pelvis is reported by Escat.[9] In his case there was a tuberculosis of one of the trochanters, followed by extension through the lymphatics to glands in relation with the bladder and ureter. These organs were involved by contiguity, the walls of the ureter infiltrated and its lumen stenosed, and nephrectomy apparently showed that there had been a direct upward extension to the renal pelvis. In another case reported by Escat and Dor,[9] bladder symptoms had persisted for thirteen years, the left ureter was stenosed and upon nephrectomy the pelvis and papillæ were involved while there were no lesions in the cortex. This they considered a typical case of ascending infection; but as the process in the pelvis was well advanced the evidence is not convincing.

Infection through the Lymphatics.—The lymphatics as a portal of infection have received little serious consideration for the reason that the lymphatic flow is *from* and *not to* the kidney. Infection by this route, described by Tendeloo and Brongersma, is not admitted by Marogna and is dismissed in a few words or ignored by most writers. The chief exponent of this route is Noël Hallé[10] who, while admitting that cortical lesions are generally of hematogenous origin, believes that most tuberculous infections of the pelvis and calices originate in the lymphatics. He also believes that the infection of the other kidney usually occurs through the lymphatics and discards Albarran's suggestion of its occurrence through a venous anastomosis between the two kidneys.

Hematogenous Infection.—There are but few at the present time who do not consider that practically all tuberculous infections of the kidney are blood borne. There is no room for doubt that such is the case when acute miliary tuberculosis of the kidneys develops in the course of a general miliary tuberculosis, and the evidence is overwhelming that in the chronic forms also the infection almost invariably comes through the arterial blood supply. This has been proven by the distribution of the lesions as found at autopsy or after nephrectomy, by clinical observation, and by animal experimentation. While it has been repeatedly shown experimentally that tubercle bacilli reaching the kidney through the renal artery may be eliminated in the urine without leaving any trace of their passage through the kidney, it has also been shown that they may be arrested in *any part* of the renal arterial system, most frequently in the glomeruli; and clinically it has been found that the cortex of the kidney is in most cases involved first, the pyramids next, and the pelvis last. Kelly and Burnam consider that infection of the pelvis and ureter in most cases would seem to be by the urine; and state that the tubercle bacilli implanted on the mucous surface pass through the epithelium and begin to produce typical tuberculous lesions in the layer of the mucosa immediately under the surface epithelium.

Pathology.—Both the acute miliary and chronic caseocavernous types of tuberculosis are found in the kidney. H. Morris,[11] summarizing the statistics of numerous authors, concludes: "(*a*) That miliary tuberculosis of the kidney is twice as common as the caseating form; (*b*) that miliary tuberculosis affects children under ten years of age in a large proportion of cases, whereas the caseous variety is at least somewhat exceptional in children below ten; (*c*) that miliary tuberculosis, with rare exceptions, affects *both* kidneys though not to an equal degree in all cases, whereas the caseating form affects both kidneys only a little more often than it does one kidney alone; (*d*) that the caseating form of the disease is more especially an affection of young and middle adult life, but occurs also in persons past middle age."

In *miliary* tuberculosis small gray or grayish-white tubercles may be found scattered throughout the kidney, but are most numerous in the cortex. Sometimes the distribution is confined to the territory supplied by one small branch of the renal artery. Each small speck corresponding to the point of lodgment of tubercle bacilli gradually increases in size, and a nodule is formed by hyperplasia of the endothelial cells lining the blood-vessel and round-cell infiltration of the connective tissue. The center of the nodule may become necrotic and these nodules are often surrounded by a hemorrhagic areola. Coming as part of a general infection, and practically invariably bilateral, giving rise to no characteristic symptoms or with the symptoms overshadowed by those of the general infection, these cases are of no surgical significance and no special treatment, other than that of the general disease, is indicated. Death usually follows in a few weeks or months.

In the *chronic caseocavernous type*, the primary lesion is again the miliary tubercle and again by far the most frequent initial site is the cortex. Sometimes the papillæ may be involved primarily—rarely the pelvis. In the cortical cases as the tubercles increase in number they coalesce, necrosis takes place in the center and cavities of various shapes and sizes are formed which are filled with cheesy material or, in case of mixed in-

fection, with pus. Coincident with the development of tuberculous nodules there is degeneration and ultimate destruction of secreting tissue. The tuberculous process may be limited to a small area of the kidney, most often in one of the poles, or may develop from separate foci in various parts of the kidney, cavities being formed which may remain distinct or fuse with others. This fusion sometimes occurs to such an extent that the greater part of, or the entire kidney, is ultimately converted into a huge, multilocular pus sac. As the process advances from the cortex the pyramids are involved at their bases and finally the process extends to the papillæ, whose apices are broken down and infection of the pelvis and ureter then follows. The kidney may be much or little enlarged, and this may be symmetrical or irregular. This is the normal evolution of originally closed parenchymatous foci. In addition to cavity formation there is often diffuse tuberculous infiltration and parenchymatous degeneration. There may also be diffuse fibrous or fibrofatty change, and there is always marked thickening of the capsule when there are adjacent subcortical foci. Comparatively rarely ulceration takes place through the capsule, giving rise to tuberculous perinephritis or perinephritic abscess. Perirenal infection may also take place by way of the blood-vessels or lymphatics.

Sometimes encapsulation takes place and the process is temporarily arrested while still confined to the cortex or to the base of the pyramid; but this is exceptional and permanent cure by this process, such as sometimes occurs in the lung, is excessively rare if, indeed, it ever occurs. Albarran has never seen a case of spontaneous healing and, as Woolsey[12] remarks, but few *if any* specimens of healed tuberculous kidneys are found, while they should be not uncommon if spontaneous recovery is common.

Ordinarily the process is steadily progressive; one or more of the abscesses break through into the pelvis, the initial subepithelial infiltration of the pelvis and ureter is succeeded by an extension of the tuberculous process to their deeper layers and to the bladder. Ulceration of the mucous surfaces then takes place and infiltration of the deeper tissues with thickening of the pelvic and ureteral walls, thus giving rise to strictures, which are common, or, very rarely, to complete occlusion of the pelvis or ureter. In either case dilatation occurs above the point of obstruction. As Keyes, Jr.[13] says: "Inasmuch as the cavity of the kidney pelvis itself often becomes almost obliterated by this process, the dilatation may affect only one portion of the kidney. Exceptionally the obstruction is in the ureter and the pelvis itself is widely dilated instead of being contracted."

When the obstruction of the pelvis or ureter is complete, we have a *closed tuberculous pyonephrosis* and the process is called *autonephrectomy*. This unusual complication is well described by Fowler[14] who finds that there are two main groups of cases—(1) those with renal distention and the presence of a tumor in the loin, the more common type and showing the so-called massive degeneration of Tuffier; and (2) those without distention, in which the kidney is atrophic. In these latter the kidney may be very small as the result of cavity formation with subsequent replacement by fatty and fibrous tissue and at operation may be found buried in dense fibrous tissue.

Primary involvement of the papillæ is rare. In the series of 100 cases observed by Kelly and Burnam the apices of the papillæ were involved in twenty-seven specimens, but in only one case was there solitary involvement of this part of the kidney. Clinically, a very large proportion of tuberculous kidneys show lesions at the apices of the papillæ, but this of course includes those secondary to extension from a cortical focus. With the primary origin in the papillæ mixed infection is usually soon added and the progress of the disease is consequently rapid.

Primary tuberculous pyelitis without involvement of other portions of the kidney is very rare. At the October, 1913, meeting of the Congrès de l'Association Française d'Urologie, at Paris, Vincent,[15] of Tours, and Gauthier[15] reported two such cases as great rarities.

The statement of the relative frequency of the forms of renal tuberculosis as met by Hallé in 100 autopsy and 100 nephrectomized kidneys furnishes considerable food for thought. He divides them into four groups, as shown in the following comparative table:

	Autopsy.	Nephrectomy.
Closed parenchymatous tuberculosis.	36	30
Tuberculous pyelitis	35	24
Mixed (parenchymatous with pyelitis)	29	42
Aberrant cases (secondary to congenital or acquired previous alterations such as lobulated, cystic, or polycystic kidney, hydronephrosis, etc.)	0	4
	100	100

One may well question the occurrence of so large a percentage of cases showing tuberculous pyelitis alone (it being assumed from the method of classification that there were no antecedent cortical foci); but since all specimens were examined by the same individual the percentage of error in classification should be the same in the two tables.

Symptoms.—These depend to a great extent on the location and extent of the lesion. If situated solely in the parenchyma there are no symptoms or they are so slight and of so general a nature that they mislead rather than point to the diagnosis and the possible rôle of the tuberculous kidney in their production is entirely overlooked. On the other hand, as soon as the papillæ or any part of the pelvis and calices become involved, characteristic symptoms—localizing, vesical, urinary—of varying degrees of severity are very soon established. The course of events with cortical lesions is well explained by Keyes, Jr., who says: "It is not generally appreciated that the variations in the patient's general health as well as in his renal or vesical symptoms are due to alterations in retention (renal or vesical) or to changes in the activity of pelvic or vesical lesions rather than to changes in the kidney parenchyma. Every case of early renal tuberculosis submitted to operation places in our hands a pathological specimen suggestive of the fact that the renal lesions are far older than the duration of the symptoms would suggest. Indeed, the mere presence of surgical tuberculosis in the parenchyma of the kidney causes no symptom. Upon this fact it is scarcely necessary to insist. The familiar case history with its exclusively vesical symptoms is sufficient evidence that the lesion in the kidney parenchyma does not make itself felt until one of two things happens. Either it extends through the capsule and excites perinephritis, or else it extends to the pelvis and there sets up a tuberculous pyelitis. Perinephritis is rare * * * tuberculous pyelitis is common. Doubtless the painful and frequent urination, which is so often the most prominent early symptom of the disease, is at the outset due entirely to tuberculosis of the pelvis and ureter."

With this introduction let us consider the symptoms in detail, under the following four headings, into which they naturally fall: General; Local; Bladder Manifestations; and Urinary Symptoms.

General Symptoms.—Often for some time before a renal lesion is suspected there are vague evidences of some constitutional disturbance. These may consist in malaise, anorexia, anemia, slight loss of weight and mild digestive disturbances, which may or may not be coupled with more or less mental and physical weakness. In some cases there is a slight afternoon or evening rise of temperature and a common diagnosis at this time is the old stand-by malaria. When such symptoms are not otherwise explicable Murphy says the first question you should ask yourself is, Is this the

initial stage of a tuberculosis? As the disease progresses the constitutional symptoms usually become more pronounced, especially as regards loss of weight and strength, the temperature ranges may remain low but are apt to be wider and often accompanied by sweats, while with the advent of mixed infection there are often chills. Usually those with pyonephrotic kidneys, especially those with mixed infection, show the most severe general symptoms. On the other hand, many patients show but little if any interference with their general health in the earlier stages, and this is occasionally true even with extensive kidney involvement.

Local Symptoms.—In some cases the first symptom which sends the patient to the surgeon is pain in the lumbar region. This may be a dull ache, a feeling of weakness in the back, or pain of a more severe character, which may remain localized or radiate down the course of the ureter. Usually pain is a late rather than an early symptom, though in Braasch's[16] report it was found early in twenty-five per cent. of the cases. Occasionally it is colicky in character suggesting stone and due to the passage of blood clot or cheesy masses through the ureter. Pain in the loin may also be due to distention of the pelvis by associated hydro- or pyonephrosis, to perinephritis, or to perinephritic abscess. When the ureter has become thickened and tends to contract there may be a dragging pain referred to the region of the kidney or corresponding to some point in the course of the ureter. Minet[17] reports such a case in which the most prominent symptom was persistent pain and occasional crises at one point along the right ureter and with no bladder symptoms for a long time, except at periods corresponding to the ureteral crises, so that the diagnosis of renal tuberculosis was long in doubt.

While the incidence of pain in the lumbar region is variable, there is almost always more or less tenderness to deep palpation and percussion, with the possible exception of certain cases in which the process is limited to the upper pole. Rarely the first symptom noted by the patient is finding a tumor in the kidney region. When tumor can be felt it may present the outline of symmetrical renal enlargement, or it may be an irregularly lobulated mass.

Bladder Manifestations.—The bladder usually furnishes the first, the most persistent, insistent, and characteristic symptoms of renal tuberculosis. In from sixty to eighty-five per cent. of the cases vesical irritability is the initial symptom and it is almost always present at some stage of the disease. This was complained of in a large proportion of Fullerton's[18] cases, was the initial symptom in approximately sixty-two per cent. of the cases studied by Rafin,[19] was the initial symptom in seventy per cent. and present at some stage in ninety per cent. of Kelly and Burnam's series, and as a primary symptom in eighty-six per cent. of the 203 cases operated upon at the Mayo Clinic and reported by Braasch. In the early stage the irritability is diurnal, later nocturnal also; and with the frequency of micturition there is associated urgency, a variable amount of pain in the bladder and end of the urethra, and often finally marked tenesmus. In one case reported by H. Morris very painful micturition occurred an average of 160 times each twenty-four hours. Upon cystoscopic examination during the early period of vesical irritation the bladder mucosa may appear normal, the frequency of urination then being explained as a reflex nervous phenomenon. As the bladder irritability increases, incontinence develops, first at night, but may soon occur at any time. It is always more marked at night and the patient may pass urine without awakening.

Urinary Symptoms.—These include polyuria, hematuria, and pyuria; while in the sediment is to be found the tubercle bacillus. *Polyuria* is generally considered to be one of the early symptoms but it is more likely that the increase in the urinary output in the early stages is more apparent than real—there being an increased number of voidings of small amounts rather than an absolute increase in the twenty-four hour quantity. Later there is usually an absolute increase brought about by the development of the interstitial nephritis which regularly accompanies tuberculous invasion of the parenchyma. In the advanced cases, while the quantity excreted may be large, perhaps even larger than that of the sound side, the percentage of solids is usually very low. Still later, as the secreting structures are gradually destroyed by the tuberculous process or by replacement fibrosis, the urinary output from the diseased kidney decreases and may finally cease altogether. *Hematuria* is almost always present at some stage and may be the first symptom noted. It is usually small in amount, the quantity being more often micro- than macroscopic. However, in some cases the hemorrhage may be severe, particularly when the apices of the pyramids are involved. When severe hemorrhages occur it is usually fairly early in the progress of the disease, they are usually intermittent and often with long periods between the attacks. Later there is usually but a moderate sprinkling of red cells along with the pus. The amount of hematuria bears little or no relation to the activities of the patient and the first hemorrhagic urine may be noted when voiding after a sound sleep as well as after a hard day's work. Braasch[20] has found that hematuria in exceptional cases may be not only the first but the only evidence of renal tuberculosis; and that in such cases the hematuria will usually be well marked and persist but a day or two, often showing but one hemorrhage. He states that of three cases of hematuria regarded on clinical examination as being essential, two were proved to be tuberculous on subsequent examination and in one the patient was reported to have died of renal and pulmonary tuberculosis. *Pyuria* varies in amount from a few scattered pus cells to the sea of pus that accompanies mixed infection of the pelvis and pyonephrosis. Rarely it is the first symptom noted by the patient. Usually vesical irritability or hematuria bring the patient for examination and the pyuria is discovered by the examiner. It is present to some degree almost invariably. Occasionally in a case where there is usually considerable pus the urine may clear at intervals, due to the temporary blocking of the ureter, all the urine then coming from the sound side; or it may practically disappear if permanent occlusion of the pelvis or ureter occurs. Of other urinary symptoms the presence of variable amounts of *albumin* needs mention, for this has often resulted in an erroneous diagnosis of Bright's disease. The frequent decrease in the amount of solids, apparent in examination of two ureter-catheter specimens, should also be remembered.

Diagnosis.—This is sometimes an easy, sometimes an extremely difficult matter. The first step consists in obtaining an adequate, detailed history, taking into consideration not only the present symptoms but also the family history, predisposing factors such as mode of life, occupation, and home conditions, the history or discoverable evidences of tuberculosis elsewhere in the body, whether active or not, and making inquiry leading to the elicitation of such early general symptoms as have already been mentioned under that heading. Continued diurnal vesical irritability, even without other positive signs, is always suggestive or renal tuberculosis when it occurs with acid urine and without local evidence or apparent cause for posterior urethritis or simple cystitis. If to this vesical irritability is added even a slight degree of pyuria of *renal* origin, with or without hematuria, one should leave no stone unturned in the attempt to satisfy one's self as to the presence or absence of renal tuberculosis; for it is upon *early* diagnosis and *early* treatment that the

patient's safety depends. The next step consists in a thorough physical examination including that of the urine, the examination of a catheterized specimen for tubercle bacilli, and cystoscopic examination of the bladder. If the bacilli are not found in stained sedimental preparations (and Braasch[21] believes, contrary to general opinion, that they can be found in practically every case of early renal tuberculosis if looked for repeatedly) guinea-pig inoculation may be resorted to, a test which Braasch has found practically infalliable. None of the tuberculin tests are reliable in the adult, as far as localization to the kidney is concerned, since there are certainly but few who do not harbor a tuberculous focus somewhere which might give a reaction. If, with vesical irritation, tubercle bacilli are demonstrated to be present, it is practically certain that there is *renal* tuberculosis; for primary tuberculosis of the bladder or its secondary involvement from any other source than the kidney is very rare. Many authors go so far as to state that bladder involvement is *always* secondary to renal infection. Tracy, for instance, considers that primary tuberculosis of the bladder "is a delusion of the diagnostician, represents a mistake in diagnosis, and is evidence of an incomplete examination." But whether tubercle bacilli have or have not been found in the urine, a cystoscopic examination is of the greatest importance and should always be made when one has the slightest suspicion of renal tuberculosis. By this means we may discover lesions of the bladder mucosa suggestive or characteristic of tuberculosis, and their situation often points at once to the diseased kidney or suggests the probability of bilateral involvement, which point may be cleared up by ureteral catheterization and examination of the separate urines; or it is found that one ureter is strictured while the other is normal in caliber, or one ureter is totally occluded. I cannot refrain from quoting Macklem's excellent description of the usual bladder findings: "Usually the superior and posterior walls show no involvement, the trigone, especially the region surrounding the ureteral orifices, displaying the most marked evidences of the secondary infection. This consists in the presence of yellowish-white miliary tubercles surrounded by a congested zone. Some will be seen to have broken down into ulcers, which are either single or multiple, show more or less infiltration according to duration, have thinly elevated edges, and irregular outlines. They are usually of small size and are frequently surrounded by other groups of miliary tubercles. The remaining mucous membrane is usually more or less congested and may exhibit varying degrees of contraction, due to a frequently coexisting pericystitis emanating from an outward extension of the inflammation." Two other conditions may sometimes be noted. One is the so-called "golf-hole" appearance of the ureter opening, due to thickening and retraction of the ureter; the other, and a very important one from the standpoint of early diagnosis, is an edema around one ureteral orifice which may often be observed before tubercles are to be found on the mucous surface. While this is not characteristic of tuberculosis it is very suggestive, especially when occurring in the presence of other suspicious symptoms. Buerger, upon several occasions, has excised a portion of this edematous tissue through the operating cystoscope and has found tubercle bacilli in the tissue, thus leading to a much earlier positive diagnosis than would have been otherwise possible. Finally, by means of the cystoscope and ureteral catheterization we are enabled to determine the functional worth of the supposedly healthy or least diseased kidney, a matter of great importance in contemplated nephrectomy. It is thus seen that even after a diagnosis of tuberculosis has been made certain by the combination of symptoms and finding the tubercle bacilli in the urine, we are dependent upon the cystoscope for the localization of the process and for aid in determining the proper course to pursue as regards treatment.

Among other diagnostic points are the finding of a thickened ureter by rectal or vaginal examination, and of nodular enlargement of the prostate or epididymis. Braasch considers that when such enlargement is found in a young adult, without recent venereal infection or *nocturnal* frequency, the diagnosis of renal tuberculosis can safely be made. On the contrary, Barney[22] studied 154 cases of epididymal tuberculosis and found the kidney involved in but eighteen, in only seven of which did he think the kidney involved first. It is necessary to add, however, that in a large proportion of the cases his opinion as to the kidney condition is based upon clinical observation rather than upon direct examination of the kidney at operation or autopsy. Cole,[23] in 1906, made a diagnosis of tuberculous kidney by means of the *x*-ray alone, and has succeeded in doing this in a number of instances since that time. Radiography, however, is seldom of value except in differential diagnosis and with tuberculous kidneys pyelography, except in the most skilled hands, is a dangerous procedure.

Closed tuberculous pyonephrosis requires special mention. Smirnow, according to Fowler, divides these cases into three groups from the standpoint of diagnosis: "(1) The bladder is tuberculous. In the region of the supposedly diseased kidney a large tumor, the pyonephrotic sac, is found. The ureter on this side is impermeable. Diagnosis easy. (2) The bladder is normal. One ureter is impermeable and on this side there is a tumor in the kidney region. Diagnosis is possible from the history of the case and symptoms referable to other organs. (3) The tuberculous involvement of the bladder is far advanced; cystoscopy is impossible. An enlarged kidney can be palpated. Diagnosis is only possible by exploratory incision, as the enlarged kidney may be only hypertrophied while the other kidney is atrophic and tuberculous."

Differential Diagnosis.—The greatest pitfall should not be, but is, cystitis. Occasionally unilateral pyelitis of non-tuberculous origin and pyonephrosis may require differentiation. In all these cases cystoscopy and ureteral catheterization combined with careful search for the tubercle bacillus, sometimes with guinea-pig inoculation, will practically always clear up the situation sooner or later and usually at once. Other conditions sometimes requiring differentiation are renal tumor and renal or ureteral calculus. In these the *x*-ray and pyelography are of assistance. The value and limitations of the *x*-ray in these cases have recently been well pointed out by Krotoszyner.[24]

Prognosis.—The prognosis in the individual case depends upon so many factors, such as the location of the lesion, the patient's occupation, his general physical condition and the surroundings in which he lives, that in one case the prognosis may be fair and in another hopeless. The prognosis as to cure without operation is practically nil; for while in rare instances total occlusion leads to the atrophic form of closed pyonephrosis, there is always a tuberculous focus remaining which may burst into activity at any moment. Keyes, Jr. and many other writers have reported cases where, after a longer or shorter period of quiescence, symptoms have reappeared and been soon followed by a fatal termination. The average expectation of life in untreated and medically treated cases has been given by various investigators as from three to five years after the beginning of symptoms.

Treatment.—There is but one method of treatment which offers any hope of permanent cure *early nephrectomy;* for by this means *and by this only* can the focus be totally eradicated. There are no spontaneous or medical cures in the sense that all tuberculous foci in an affected kidney are completely destroyed, although there are often remissions of symptoms which may, in rare instances, extend over a period of years. Medical treatment has no place in

the treatment of renal tuberculosis except as an adjunct to surgery and in cases which are inoperable when first seen by the surgeon. One could not ask better proof of the truth of this statement than is shown by the statistics compiled by Wildbolz[26] of 316 cases treated non-surgically in Switzerland under what are supposed to be the most perfect hygienic and climatic conditions obtainable. Of these 316 cases *ninety per cent. died within five years* after the onset of the disease; in but five per cent. had all symptoms disappeared over five years; and *only one case was entirely well.* And yet, Why are these cases so late in getting to the surgeon? It is partly because the general practitioner does not recognize the significance of the early vesical irritability and because, as Braasch says, there exists a widespread belief that renal tuberculosis can frequently be cured by means other than surgical, particularly through the use of tuberculin. Israel, in the light of his very extensive experience, has come to the conclusion that tuberculin is of absolutely no value in these cases and should *never* be used as a curative agent, not even in the earliest stages. There are no drugs which have the slightest effect upon the progress of a tuberculous process in the kidney, hence medical treatment is limited to those measures—dietetic, hygienic, climatic—which help build up the patient's general health and natural powers of resistance and to the treatment of complications or meeting other indications as they arise. To procrastinate under the guise of employing medical treatment in the early stages of the disease is to deprive the patient of the only chance he has for its total eradication; for, as in the case of "watching" a supposedly benign tumor of the breast one has no means of knowing the precise time when the change to malignancy takes place, since no characteristic symptoms are to be found until long *after* the change has occurred, so in the medical treatment of a case of renal tuberculosis it is only after secondary infection of other structures is well established *and begins to give symptoms* that the spread of the disease can be appreciated.

We then come back to nephrectomy as the treatment *par excellence*, it always being understood that the other kidney is present and functionally competent. In the early cases and with the other kidney healthy there should certainly be no delay in removing the diseased organ. Nephrectomy should also be done even when there is some involvement of the other kidney if functional tests show that the better kidney is able to take up the total burden of urinary secretion; for often that kidney has been doing all or most of the work and it has also been shown that with the hyperemia accompanying the development of compensatory hypertrophy there often occurs a marked amelioration or even occasionally a total cessation of symptoms from the remaining kidney. Abadie[26] remarks that at different Congresses how *early* one is justified in removing a tuberculous kidney has often been discussed, but he asks "Just at what moment is one justified in *still* removing a tuberculous kidney with a valid hope of cure?" For him there is but one absolute contraindication—bilateral involvement with insufficiency of the kidney least affected. Other contraindications may be: advanced pulmonary tuberculosis, marked bilateral involvement, and multiple tuberculous foci elsewhere. In some cases, as with mixed infection of a tuberculous pyonephrosis or when, for any reason, the patient is in very poor condition, a preliminary *nephrotomy* with drainage may be advisable, but the kidney should be removed at a secondary operation as soon as possible. *Partial nephrectomy*, when the infection seemed limited to one pole, has been advocated by some; but since nothing less than microscopical examination of the entire kidney will furnish positive proof that there is no other focus, this procedure is to be absolutely condemned.

The method of treating the ureter varies with different surgeons. Some remove it *in toto;* some inject ninety-five per cent. carbolic, tie it, and leave it *in situ;* while others inject carbolic and suture it into the angle of the wound. Lilienthal,[27] in 1911, made a strong plea for its total removal when diseased or badly drained because of stricture at its lower end. Later, Tracy insisted upon its complete removal in every case and Lilienthal, in a later communication, states that he has done this operation about twenty times and in each instance it has been most satisfactory. As a rule, the ureter as well as the kidney should certainly be removed; for otherwise, and especially when there are strictures at the lower end, a persistent tuberculous sinus may result, while in addition one is deliberately leaving a focus from which further infection may proceed; and although the ureter *may* give no trouble and the bladder symptoms often clear up after the kidney has been removed, there is no reason why one should heedlessly invite possible disaster by leaving an infected ureter and *hoping* no harm will come from it. Take it out and be *sure* of it! Without removal of the ureter fistulæ are of frequent occurrence. This is well shown by Israel's statistics, quoted by Lévy-Weissman. In 11.5 per cent. of 1,023 nephrectomies for renal tuberculosis, fistulæ occurred, some of which persisted for a number of years. Reflex of urine has also been met with occasionally. It is thus seen that in many cases persistent fistulæ may entail a secondary operation if complete nephroureterectomy is not done in the first place. (For technique see article on *Nephrectomy.*)

Most operators have drained the lumbar wound if the perinephritic tissues have been infiltrated or if there has been any soiling with tuberculous material; but W. J. Mayo[28] reports that since 1910 such wounds at the Mayo Clinic have been filled with salt solution and closed without drainage, and that the results have been much better than formerly when it was the rule to drain.

Results of Treatment.—The results in medically treated cases have already been mentioned. With nephrectomy the primary mortality in early cases where the disease is confined to one kidney is practically nil. In large series of cases, comprising those of all stages in which nephrectomy has been done, the primary mortality in recent statistics has ranged from 2.9 per cent. for 203 nephrectomies at the Mayo Clinic to seven per cent. as computed by Legueu in combining the statistics of many European surgeons. The average primary mortality seems to be about four per cent. The secondary mortality varies widely, depending upon the duration of the disease at the time of operation and the degree of secondary involvement of the bladder and other structures. Braasch reports that of the 203 cases of renal tuberculosis of all types and degrees of involvement upon whom nephrectomy had been done at the Mayo Clinic, seventy per cent. had been traced. Of these eighteen per cent. were reported dead; and of this eighteen per cent., sixty per cent. had died during the first year after operation and fifteen per cent. had lived over three years. Of the eighty-two per cent. remaining alive, all but thirteen per cent. reported improvement or recovery from their previous bladder symptoms. He believes that we can expect a permanent cure in fully seventy-five per cent. of the patients operated on. Kelly and Burnam report a primary death rate in 100 cases of four per cent.; a secondary mortality, covering a period of from one to nearly twenty years, of 10.9 per cent., and a rate of cure of 81.9 per cent. Compare these results with those shown in Wildbolz's statistics of medically treated cases as quoted above. The conclusion is inevitable that the successful treatment of renal tuberculosis predicates two things: early diagnosis, and early nephrectomy. As Gordon[29] has said, the importance of early diagnosis of tuberculosis is fully recognized when the lungs are involved. It should be as fully recognized when its main focus is

in the kidney; for it is usually unilateral at first, when the whole focus can be removed and the patient cured. When early diagnosis and early nephrectomy are combined all statistics show an almost negligible primary mortality and a very high percentage of permanent cures; with delay in either of these factors the percentage of cures decreases with startling rapidity.

WESLEY GROVE VINCENT.

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Kidneys, Tumors of the.—The kidney is the seat of tumor growth much more rarely than would be expected. This is strikingly shown by W. R. Williams's[1] statistics of malignant tumors occurring in adults. He found that in a series of 8,371 cases of malignant tumors of all parts of the body only twenty-five involved the kidney. Both benign and malignant growths are occasionally found.

BENIGN GROWTHS of any consequence are rare and unless they have undergone malignant change few, except those situated in the pelvis, require surgical intervention. Benign growths seldom reach any considerable size, but few of them give symptoms, and they are usually discovered by accident in the course of operation for some other renal condition or are autopsy findings. Among those sometimes found are fibromata, lipomata, myxomata, papillomata, angiomata, encapsulated adenomata, and dermoids. Papillomata and, occasionally, angiomata are found in the pelvis and of these the papillomata, together with adenomata developing in the parenchyma, are especially prone to malignant change. The papillomata usually develop slowly but, with angiomata, are the most likely to cause symptoms, particularly hematuria. This is sometimes very profuse and may be accompanied by considerable pain partially due to intermittent blocking of the ureter with clots and the ureteral colic which marks their passage to the bladder. When benign tumors cause symptoms they should always be removed, not only to afford symptomatic relief but also because of the marked tendency of symptom-producing benign growths to become malignant.

Mention must also be made of the inclusion tumors from the mesonephros, Wolffian body, and suprarenal, of simple cysts, and of polycystic kidney.

Simple cysts found in the kidney include dermoids (so rare that Kelly and Burnam[2] could find but three cases reported in the literature, though lately Baldwin[3] has found five cases in the literature and reports one more), retention cysts, and serous or serosanguineous cysts. The retention cysts may be very small or reach a considerable size, depending upon the extent of blocking of the tubules or one or more papillæ. Serous or serosanguineous cysts are also rare, may be very small or of such enormous size as to nearly fill the abdomen. When large and occurring in females they are usually mistaken for ovarian cysts. About forty cases have been reported and nearly half of these have originated in the lower pole. Besides these, numerous small cysts are sometimes found beneath the capsule as the result of aseptic embolic infarction; while there are also occasionally cysts of parasitic origin, particularly echinococcus, these latter being not at all infrequent in some countries.

Polycystic kidneys[4] may be of congenital origin or may be due to true tumor growth—cystadenoma. When congenital the disease is almost invariably bilateral, though not necessarily affecting the two kidneys to an equal degree. Polycystic disease is usually observed in early life or not until the age of forty to sixty. The cysts vary widely in size, some being of microscopic proportions, others of various dimensions up to the size of a walnut or even larger. They may be few in number or almost innumerable; the kidney may be slightly enlarged or reach enormous proportions, even to the extent of impeding delivery of the fetus. Numerous theories have been suggested as to the causation of polycystic kidneys. Virchow held that there was an interstitial inflammation of the papillæ resulting in occlusion of many of the tubules; but the theory most generally accepted at the present time is that there has been a failure of junction of the secreting and collecting tubules, especially as there are often associated developmental anomalies elsewhere.

Symptoms and Diagnosis.—With congenital polycystic disease many of these fetuses are born dead, most of the others die from anuria or uremia shortly after birth, while a few survive for a variable number of months or even years, these latter representing the cases where one kidney at least has not been extensively diseased at birth; but since the disease is always progressive the span of life is usually short. In those cases which are fatal soon after birth there is usually a palpable tumor in one or both kidney regions and early marked symptoms of renal insufficiency. When polycystic disease develops in the adult the symptoms are very variable and positive diagnosis has seldom been made without exploratory operation. The enlargement of the kidneys may be very slow and unaccompanied by symptoms sufficient to call attention to kidney impairment until the process is far advanced. The late symptoms and physical signs consist of renal enlargement, discoverable by palpation or *x*-ray examination, with or without collargol injection of the pelvis, and the group of symptoms included in the classical descriptions of the later stages of interstitial nephritis. Pain may or may not be present and the same may be said of hematuria, though the latter is rather rare. Differentiation from other renal lesions, particularly closed hydronephrosis, is sometimes possible by cystoscopy, ureteral catheterization, and functional tests. If these kidneys become infected the symptoms of sepsis—local pain, tenderness, and systemic reaction—are superadded.

Treatment.—The congenital, bilateral polycystic

cases are practically hopeless. When polycystic disease has occurred later in life and the other kidney has appeared to be functionally competent, nephrectomy has occasionally been practised but with very discouraging results. Albarran and Imbert (quoted by Kelly and Burnam) have reported thirty-four nephrectomies with nine primary deaths, one a few weeks after operation, and four within a year; while only two of the cases followed up lived seven years. Other measures include decapsulation, nephrotomy with establishment of copious drainage, and puncture of the larger cysts, none of which procedures offer much hope of more than temporary improvement, and practically none of cure. Simple cysts may sometimes be enucleated, as has been reported by Tuffier, Albarran, and others, may be treated by nephrotomy and drainage, by partial nephrectomy if limited to one pole, or by total nephrectomy if the other kidney is functionally competent. C. E. Barnett[5] has collected statistics of 251 American cases which he considered authentic: 150 bilateral, and 101 unilateral. Of these, nine unilateral cases, where nephrectomy was done, were still alive.

Malignant Growths.—The primary malignant growths affecting the parenchyma include hypernephroma, sarcoma, carcinoma, and mixed tumors of embryogenetic origin—embryomas, Wilms's tumors. In the pelvis, carcinomata and papillomata apparently follow chronic irritation, usually due to stone, while very rarely squamous-celled epithelioma of embryogenetic origin has been reported. With pelvic growths of the papillary type, transplantation of tumor tissue and development of secondary growths in the ureters and bladder is not at all infrequent. W. E. Lower[6] reports a remarkable case of this nature, summarizes eighteen others from the literature, and appends an exhaustive bibliography. Primary sarcoma originating in the pelvis is exceedingly rare. Secondary growths, both sarcoma and carcinoma, are not infrequent and reach the kidney by metastasis or by direct extension from neighboring organs. It is hard to imagine a wider variance of opinion as to the proper classification and relative frequency of the malignant growths occurring in the kidney than has existed and still seems to exist. There is but one point upon which all pathologists seem to agree, namely, that the most frequent tumor is that commonly called hypernephroma.

Hypernephromata.—In various recent statistics from fifty to seventy-five per cent. of all malignant tumors studied appear in the tabulation as hypernephromata; and yet the origin of these tumors is still in question and the histological structure is so diverse, especially in the larger tumors, that areas characteristic of various types of sarcoma and carcinoma are often found in different parts of the same tumor. It is undoubtedly this polymorphism of cells in hypernephromata that accounts for the fact that in former years many more cases of sarcoma of the kidney were reported than is the case at present, sections of those tumors happening to be made in areas where the growth presented the histological characteristics of sarcoma. It is also likely that these tumors are responsible for the present conflicting statements as to the relative frequency of sarcoma and carcinoma, some eminent pathologists and clinicians holding that sarcoma is frequently encountered and carcinoma comparatively rare while others, equally eminent, hold that most of the reported sarcomata belong in the group of hypernephromata and that carcinomata rank next to hypernephromata in point of frequency. The recognition of hypernephroma as a distinct type of tumor dates from 1883 when Grawitz[7] first described them, hence, they have frequently been called Grawitzian tumors. He concluded that these tumors owed their origin to atypical development of aberrant adrenal gland tissue—adrenal rests—hence, designated them hypernephromata. His reasons for assuming this origin are summed up by Wilson[8] as follows: "(1) the tumors are situated immediately beneath the capsule of the kidney; (2) their cells are different from those of the epithelium of the uriniferous tubules; (3) the cells contain fat which is normally absent from the renal epithelium but frequently present in the suprarenal epithelium; (4) the capsule of the tumor is similar to that which is found around suprarenal rests within the kidney but which are not changed into tumors; (5) the cells of the tumors are sometimes disposed in more or less regular cordons which resemble those of the suprarenal cortex." This theory was accepted almost without question, except by Sudeck,[9] until 1908 when Stoerck[7] published the results of his observations, apparently effectively disposed of the adrenal rest theory, and offered one of his own. Stoerck's objections to Grawitz's theory are stated by Wilson as follows: "(1) the Grawitzian tumors most frequently develop at the lower pole of the kidney where adrenal rests are not found; (2) the so-called fat of the cells of the Grawitzian tumors is usually not fat but a vacuolation related to the glycogen content of the cells; (3) the Grawitzian tumor is a tumor of the renal cortex and not of the renal capsule in which adrenal rests are usually found; and that (4) though the Grawitzian tumors do frequently contain cordons which, however, only remotely resemble those found in the suprarenal, yet they also almost invariably contain tubules, the analogues of which are never seen either in the normal suprarenal or in the tumors of that gland." The new theory advanced by Stoerck[10] was that hypernephromata develop from regenerating convoluted tubules in an atrophic kidney—a far from convincing conclusion. Wilson, who has had an unusual opportunity to study these growths, has urged the hypothesis that these tumors "are mesotheliomas, or more definitely nephromas; that is, that they are elaborated from masses of nephrogenic tissue which have never become connected with the renal pelvis and which have never attained adult type either in form or function." He also states his belief that as the evidence accumulates it will show that the so-called Grawitzian tumors have nothing whatever to do with a suprarenal origin. He found but one tumor from inclusion of adrenal tissue in the renal cortex in the 92 malignant renal tumor specimens representing the entire operative and autopsy material of the Mayo Clinic up to the latter part of the year 1912, while Glynn could collect but 17 cases from the literature, to which number he added 2 of his own. The diagnoses in the 92 cases from the Mayo Clinic reported by Wilson were: mesothelioma (hypernephroma) 71; sarcoma, 7; carcinoma of the renal pelvis, 4; papilloma of renal pelvis, 3; embryoma, 3; Wolffian tumor, adenoma, fibroma, and squamous-celled epithelioma, 1 each. Hypernephromata originate in any portion of the renal cortex, most frequently at or near the lower pole. Those occurring in the upper pole of the kidney are usually small, well encapsulated, often markedly resemble adrenal cortical tissue, and are apt to be benign. Those occurring elsewhere also originally have a definite capsule, may be small but more often reach a large and sometimes enormous size, may contain some areas suggesting adrenal tissue but the bulk of the tumor is composed of tissue of an entirely different character. These growths may be benign or they may merely remain quiescent for an indeterminate period, finally showing characteristics of marked malignancy, rapidly developing to a large size, invading the pelvis and renal vein, and giving rise to metastases in various parts of the body, particularly the lungs and bones. Metastasis is usually through the blood stream, the neighboring lymphatic glands often escaping involvement even in cases where there are rather extensive metastases elsewhere. Hemorrhage into the pelvis is absent, moderate, or excessive, depending upon the situation of the tumor in the kidney, the stage of development, the rapidity of the

growth, and the type of predominating cellular elements.

Sarcomata.—These are usually found in childhood and early adult life, though it is probable that most of those reported in childhood would now be classified as embryomas, while their relation to hypernephromata has already been referred to. Sarcoma usually begins in the capsule and invades the parenchyma secondarily but occasionally these tumors originate in the deeper structures. Sometimes their derivation from pre-existing fibromas or other benign types of tumors can be demonstrated. Both large and small round-celled and the spindle-celled types are seen. These growths are very apt to involve the other kidney secondarily. Murphy[11] has found that sarcoma almost always recurs in the other kidney if the patient lives a period of three years. If the tumor is composed principally of small round cells, growth is usually rapid and large tumors are formed; but with other types development is said to be comparatively slow and the tumors usually do not attain great size. Hemorrhage into the pelvis is usually less severe than in carcinoma.

Carcinomata.—These are sometimes primary but more often secondary. The primary growths, except the pelvic tumors already referred to, originate in the parenchyma, sometimes from pre-existing adenomata, the cells usually presenting the arrangement of adenocarcinoma, occasionally of alveolar carcinoma, and they infiltrate toward both capsule and pelvis. In one of my nephrectomies, hitherto unreported, the tumor was found to be the very rare primary scirrhous carcinoma of the kidney. This specimen was studied and the diagnosis confirmed by H. T. Brooks. Carcinomata seldom reach large size because of the early metastasis which practically always takes place. Metastases may be widespread and when the growth penetrates the capsule the overlying colon and other adjacent structures are often directly invaded. Since cancer cells are not so stable as those of mesoblastic origin, necrosis and consequent presence of pus in the urine is more common with these than with other types of renal tumor. Certain of the carcinomata resemble the large hypernephromata in that they invade the pelvis and renal vein and upon section show many large hemorrhagic areas.

Embryomata.—These are the usual malignant renal tumors of childhood but are excessively rare in the adult. One or both kidneys may be involved. These tumors represent malignant degeneration, to a greater or lesser degree, of *all* the elements concerned in the formation of the kidney. They are often very large and grow into the pelvis and renal vein, in this respect resembling the hypernephromata; but the formation of metastases occurs relatively late and hematuria is much less frequent, often the only symptoms being tumor and cachexia.

Symptoms.—The classical symptoms are hematuria, tumor, pain, and cachexia. *Hematuria* is the most important for many reasons. It is often the first symptom noted by the patient, often occurs long before the tumor is palpable and before the onset of pain, and may thus serve to call the surgeon's attention to the need for cystoscopic examination with consequent determination of the renal origin of the bleeding and exploratory operation before metastasis has occurred. The amount of hematuria varies with the type of tumor and its situation in the kidney. When the pelvis is invaded the hemorrhage is usually severe. Among the characteristics of tumor hemorrhage, outside of its quantity, are its intermittence, its spontaneous and often painless appearance, apparently having no relation to the activities of the patient and often occurring at night, and, finally, clot formation giving rise to earthworm-like casts of the ureter, for it has been my experience that these are rarely seen except with the copious bleeding of renal tumor. Braasch,[12] in an article presenting the clinical data of 83 cases of malignant tumors of the kidney operated upon at the Mayo Clinic up to July 1, 1912, found that hematuria was given as a symptom observed by the patient in 53 cases, as a primary symptom in 39 and as the only symptom in 10 of the cases. *Tumor*, usually the first symptom noted in children, may be an early or very late symptom in adults, while in the case of small tumors and in many of those involving the upper pole it may never be possible to determine by palpation or percussion that there is a pathological enlargement of the kidney. Braasch's statistics reported a palpable tumor in 65 of the 83 patients; its existence was known to 28 patients; it was the first evidence of disease in 12 cases; 37 patients were unaware of its existence; and it was given as the only symptom by 5 patients. *Pain* is a very variable and often very misleading symptom. It is misleading for the reason that it is so often referred to various other regions of the abdomen. At first slight, and better described as a dull ache than as actual pain while the tumor merely causes slightly increased intrarenal tension, it usually later becomes rather severe, may radiate in various directions, is often lancinating in character, and when clots pass through the ureter may simulate the colic of calculous disease. On the other hand, even with very large tumors there may be little or no pain; and this is especially true with the embryomas of childhood. Braasch found abdominal pain of varying degree was complained of by 68 of the 83 patients; it was given as the primary symptom by 27 and as the only symptom by 14. The pain was referred to the affected kidney region in 50 and elsewhere in 33 of the cases. *Cachexia*, usually a late symptom, may occur early or even be the first symptom noted. Besides these symptoms, metastasis, particularly in bone or in the lungs, may serve to call attention to the kidney; while there are also certain circulatory disturbances of sinister significance, such as dilatation of the veins of the scrotum, the otherwise inexplicable development of hemorrhoids and especially of varicocele in a man over forty, and the dilatation of the veins around the ureter and the base of the bladder generally.

Diagnosis.—The three cardinal symptoms, hematuria, tumor, and pain, are *all* present in hardly more than one-third of the cases, and this includes many who have already reached the inoperable stage. Diagnosis is thus based upon the presence of one or more of the symptoms enumerated above, upon cystoscopy, usually with ureteral catheterization, and, occasionally at least, upon pyelography. Functional tests are not to be too much relied upon in these cases for it has been repeatedly shown that even with extensive invasion of the kidney by malignant growths its functional activity may apparently be in nowise impaired. Tumor of the kidney must be differentiated from other renal lesions, from retroperitoneal tumors of the lymph glands and from enlargements, benign or malignant, of the spleen, liver, gall-bladder, mesentery, and colon.

Treatment.—Symptoms exciting even suspicion of malignancy in the kidney warrant exploratory operation. When malignant growth is found, if the other kidney is functionally competent and if the growth has not invaded the surrounding tissues or known to have given rise to metastases, the kidney should be removed. No other treatment is conceivable under such circumstances. If, after nephrectomy, irremovable metastatic involvement is discovered, and in cases found to have reached an inoperable stage when first seen, the *x*-ray and radium may be tried, but with practically no hope of a favorable outcome.

Prognosis.—This is always bad unless nephrectomy is done very early. Braasch's report of the results at the Mayo Clinic shows that of 61 patients in whom nephrectomy was done 7 died in the hospital. Of the others, 51 were traced. Of these, 10 were operated upon less than a year previously, 17 were alive more than one year, 12 after three years,

4 after five or more years, and 1 after eight years. It will thus be seen that the only hope of permanent cure lies in earlier diagnosis and prompt nephrectomy while the growth is still localized.

WESLEY GROVE VINCENT.

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Kinases.—Certain indefinite substances of an enzyme-like nature are called kinases because their presence is necessary for the activation of zymogens, that is, precursors of enzymes. The best known example of a kinase is that of enterokinase which has the power of transforming trypsinogen—the precursor of trypsin and without action upon proteins—into trypsin an enzyme with a very marked digestive power upon protein. Again it has been assumed that a kinase, thrombokinase, is necessary for the transformation of prothrombin into thrombin during blood coagulation. In the latter instance the kinase is furnished by the form elements of the blood. Enterokinase as its name implies is furnished by the mucous membrane of the intestine and hence comes into direct contact with the pancreatic juice as the latter is poured in the intestinal lumen. See *Enterokinase* and *Enzymes*.

F. P. UNDERHILL.

Kinesthesia.—The term is plain Greek for the "feeling of movement," and motion-sensation is for the most part what this word, more and more frequent and as important in philosophy as in medicine, means. In defining the denotation of the term, however, it must be noted that nowadays "sensation" needs not to be actually sensed, *i.e.* conscious, for most sensory, that is, afferent, neurokinesis (neurility) is not directly experienced, the "sense" organs being now technically spoken of as receptors, on the other hand, kinesthesia stands for neurokinesis which produces only molecular movement and so only increased tonus (and not molar "movement") in the body by way of the muscles; furthermore, recent research suggests strongly (see below) that a phase of kinesthesia is preventive of movement, that is inhibitory, and not actuative at all—in the modern sense of inhibition by an active process. Lastly, it is accurate if not traditional to include tactile sensations in kinesthesia, since they require movement (Van Biervliet) for their origination. With these four adaptations of the term movement-sensation, each in accord with modern neurologic terminology and understanding, the convenient term kinesthesia is entirely satisfactory as terms go in our complex modern science. Philosophically and psychologically kinesthesia gets an ever increasing notice in part from the circumstance, basal in the all-important relations of body and mind, that it is the chief sense, in fact the sense proper, by which subjective bodily movement in space is somehow made concomitant or correlative to the subjective mental "movement" (succession) in time, James's "stream of consciousness" in the flow of which all our being in mortal days is passed. Such being obviously the case, it is not strange that advanced thinkers (in Europe for example Ribot, McDougall, Bergson) are attempting its more precise correlation with the fundamental being of the empirical mind. In medicine the importance of kinesthesia is not only academically scientific but underlies various aspects of diagnosis—gaits, postures, fatigue, hysterical paralysis, abulia, genetic physiology, feeble-mindedness perhaps, to a greater or a less extent, to cite examples almost at random. Altogether, it is obvious that kinesthesia is the most important human "sense."

Let us first summarize what little is known about the kinesthetic receptors. These are located more or less abundantly in all parts of the human action-system (joints, muscles, and tendons), in the bones, and in the skin over the moving parts especially. There is still much uncertainty as to their respective functions and as to their precise respective frequency in different parts and tissues.

Compared with the great sense-organs of vision and of hearing, these sensory nerve-endings in the muscles, tendons, and joints are simple structures. They are, as Huber calls them, the "peripheral teleodendra or dendrites of peripheral sensory neurones." The forms of the nerve-endings already described by histologists are various and consist of two general varieties free and encapsulated. The free endings have not been discovered in muscle or tendons, but they occur in mucosæ and in epithelium.

Afferent Endings in Muscle.—These are of several forms whose shapes more or less merge into each other. They are probably all actuated by mechanical pressure.

The cylindric end-bulb of Krause is found in cross-striated muscle and in tendon as well as in the skin and mucous membranes. It consists of a thin nucleated capsule investing a semi-fluid core containing the nerve-fiber. It is obvious that such an instrument among the fibers of muscle or tendon will be stimulated when the muscle hardens in contraction or when the fibrous bundles of the tendon are drawn together as the tendon is put on stretch. The Vater-Pacinian corpuscle is built on the same plan as the preceding, but it is on a larger scale and more elaborate. They are sometimes 3 mm. long and 1 or 2 broad and have as many as 60 fibrous lamellæ, each of which according to Schwalbe is covered on both surfaces by a layer of endothelial plates. These end-organs are of many varieties and are found in many kinds of places. They are in the skin especially of the foot and the hand near the joints and particularly on the flexor sides of the latter, in the periosteum of the bones, in the tendons of intermuscular septa, in the muscles themselves, and in the coverings of the viscera and of the nerves. Of a different nature (and function who can doubt?) are the neuromuscular and neurotendinous end-organs described by Sherrington and Golgi. Instead of being compact and rounded organs, these apparently are the means by which the neve ends freely among the muscular and tendinous fibers. These are the so-called muscle-spindles of Kühne and Sherrington. To each of these end-organs go two, three, or four large medullated nerve-fibers, which, after dividing, end in fibrils wound about the fibers of the muscle or else in irregular discs. They are found in nearly all cross-striated muscle save the intrinsic eye-muscles and those of the tongue and larynx. They are especially abundant in the delicate muscles of the hand and the foot. Kerschner supposes that these are stimulated by the electrical action-current of the muscle rather than by compression. It is suggestive that these are found only in cross-striated voluntary muscle. Perhaps they represent, therefore, the active con-

traction of the muscle rather than its passive movement.

Afferent Endings in Tendons.—The neurotendinous nerve end-organs ("the Golgi organs" of Sherrington) are constructed on a similar general plan. These are found only in tendons and they too are especially numerous in connection with the small muscles of the hand and foot.

The Afferent Endings in the Joints, Etc.—Less is known about these than about the end-organs of the muscles and tendons. Kölliker has described the sensory nerves of bone. In the periosteum nerves are also found, but they are smaller and less numerous. There are in the joints the so-called articular end-bulbs which are in connection with the Pacinian corpuscles already described. The four articular regions (bone, periosteum, synovial membrane, and skin over the joints) probably combine to send to the brain important knowledge of the movements of the limb at a joint.

Kinesthetic Function.—Such are the most important of the known afferent organs serving the kinesthetic sense. The general purpose of all these afferent impulses is to furnish the person information as to the postures and relative activity of his limbs and other bodily muscular parts. More important than these ideas of posture ordinarily are the impressions we receive from these end-organs concerning the movements of our limbs and muscles, active or passive, of which the active are the more important. Muscular action, reflex or voluntary, depends for its usefulness in nearly all cases upon its guiding coordination from the central nervous system. In the complex voluntary actions of life especially one sees the essential importance of these myo-tendo-articular impulses or sensations, for skill, culture, and even civilization itself in part depends on the fine adjustment of voluntary muscles in ever new and more delicate ways. Imagine a "laborer" accustomed only to the rough use of the pick and shovel in a trench, attempting to engrave a delicate monogram on a small seal-ring. The inability in such a case might be due wholly to the lack of this complex sense of delicate voluntary movement. These conditions are present everywhere and always in our motor activities. Take for another example the act of walking. This is almost a reflex action in the person more than three years old. As one walks, continuous streams of impulses are passing upward into the gray matter of several segments of the cord and into the cerebelum and probably into the posterior and anterior central cortex cerebri. These come from every part of every muscle and tendon of the legs and from many of those of the trunk and neck engaged in the body's equilibrium. From all the joints concerned (hip-joints, knees, ankles, feet, spine, etc.) other sets of impulses pass similarly, and from the skin, especially over the joints and wherever it comes in contact with our garments. Moreover, we are kept dimly aware of the nature of the path we walk, whether hard or soft or rough or smooth, by these same sets of impulses. These too help reflexly to direct the spinal and other centers in their complex task of control over these multifarious walking-parts. One may similarly trace the same process in speaking, swallowing, chewing, and numerous other movements, as well as in thousands of purely voluntary actions known to the many trades, occupations, and amusements. It is, in short, only on the information furnished by these numberless incoming messages that the centers directing movement can do their work. When we make voluntary movements, especially with the arms and hands, the eyes usually follow the movements and we are apt to think that it is by vision that they are directed. They, however, can be made even better in many cases after some practice without any use of the eyes whatever. Unless there were sent into the kinesthetic centers information of an exact nature concerning the relative degree of contraction of each muscle-fiber, these central motor cells could not properly actuate the muscles. A partly contracted fiber, for example, would need a different degree of stimulus from one contracted fully. Not only must a number of different muscles be made to contract, but each one often in a particular way, hard enough but not too hard and each at exactly the right time and for exactly the right period. In short, a maze of relations exists which would make of a movement not thus minutely directed by afferent messages a mere jerk or convulsion. Never would we have the wonderfully adapted, perfect, and certain action we are familiar with. The concertos of de Pachmann differ from the drumming of our fair but misguided neighbor in the next house chiefly because in de Pachmann this sense we are considering is developed to its human limit, while in her apparently it is not.

Another use of the muscular nerve impulses combined with those from the tendons, joints, etc., is the direction of the power of contraction needful to overcome a required resistance, as, for example, that of gravity in lifting a weight. This estimate is made by the intellectual "centers" of the brain, but only from repeated experiences given through the afferent muscular and other senses. The effort is expended under the guidance of impulses coming from the contracting muscle.

That kinesthesia has paths of its own up the spinal cord is made evident by the occasional cases in which this sense alone is lost, those of the skin, the epicritic, sensations being retained. On the other hand, the discriminating sensitivity of the skin, or some of its numerous and complex aspects, may be disturbed or lost and kinesthesia preserved entirely normal.

In order to appreciate the necessary way of considering (as a matter of physiologic habit, so to say), where the "center" of the kinesthetic sense may be, it is needful to consider the status of this sense in comparison with others. When its relative nature is considered, it is at once obvious that it can have no sharply delimited region for its proper integration, since, on one hand, practically all parts of the body (muscle, skin, joints, bones, and tendons especially) are concerned in its reception and forwarding inward, and, on the other hand, every aspect and phase of mind and most all active tissues of the body, are concerned intimately with its central functions, since mind has universal muscular reference, is inherently motor in its physical relationship. We cannot imagine clearly a mental process without the innervation of its expression-mechanism. On the other side, body without universal movement is without its meaning, its final purpose; is dead and not a body properly speaking, at all, but a cadaver, a corpse. For reasons, then, which the foregoing suggests only most remotely and inadequately, kinesthesias "center" must be the whole great cortex, the upper (neopallium) layers and the lower (archepallium) of the cortex cerebri.

Still, in a sense which it would be pedantic at the present time to attempt to explain definitely, the anterior and posterior central convolutions, the region, mesial as well as parietal, on all sides of Rolando's fissure, is in some way, a special kinesthetic center. Adequate stimulation here produces in the highest mammals twitching of the various muscular parts of the body, and overstimulation or stimuli diffused across country, so to say, by fatigue, almost universal convulsions. In some sense then the Rolandic region is the kinesthetic center, since in popular traditional estimation (see the writer's "Notes on the Neurology of Voluntary Movement, *Medical Record*, May 18, 1912, pp. 927–939, to the contrary) this region is "the center of voluntary movement." Yet this is a relic certainly of a phrenology almost as crass as that of Goll and Spurzheim or that of Des Cartes's pretended loca-

tion of the soul in the little pineal gland—a statement this truly learned philosopher never could have really believed any more than that monkeys and dogs and horses were wholly "unconscious automata," as he found it expedient to claim that he thought.

No one to-day can be far wrong, then, who thinks the whole cerebral cortex the representative of the afferent as well as the efferent neurility which stands for the body's moments in our universal (mental) space of three dimensions. It is now fairly certain that these essential impulses integrating the body's less habitual movements pass, part through the cerebellum and part directly through the brain-stem into the optic thalamus. There apparently they are coordinated with the other sensory impressions and are distributed, as part of the very complex cortical radiations, into every portion of the great-cortex neurility reservoir, beneath, above, and on every side in every direction. Just what part, if any, the adjacent corpus striatum takes in this essential coordination and distribution of the kinesthetic intelligence, remains to be demonstrated. Many further details have been printed (for example by Bastian, Lewandowsky, v. Bechterew, Cajal, Starr) but so great is the lack of agreement up to this time that the minutiæ may be properly omitted from this brief sketch.

Experiments (well confirmed by other evidence) made by the writer recently and published (*Journal für Psychologie und Neurologie*, Leipzig, Bd. xx., Hft. 1 u. 2, 1913, S. 62–73) suggests very strongly that kinesthesia is in two phases. One of these has *actuating* influence continually on the voluntary musculature; is intimately related to the visual and, to a less extent, to the auditory impressions; and is *essentially subconscious*. The other kinesthetic phase appears to be, on the other hand, inherently *inhibitory* in its influence on the action-system of any particular moment of behavior; is the essence of personal voluntary movement and so is eminently *conscious whenever not drowned out by the flooding experience of vision*. The fusion of these two phases of the movement-sense in current voluntary control constitutes the essence of (motor) skill: which may be spoken of as a trained fusion, then of the extrinsic motor ideas and the intrinsic inhibitory conscious control.

Just as, psychologically considered, vision is undoubtedly the "queen" of the senses, so physiologically the processes inherently relating to movement, posture, weight, spatiality, etc., are assuredly the most important. In the universal integration of sensations, vision in a way may even be considered the mental homologue of the bodily kinesthesia as a little thought readily shows. Only now are educators beginning to relaize the indispensable usefulness always and everywhere of kinesthesia, the "feelings of movement." Kinesthesia is about, however, to come into its own as the primary and essential sense. Without it, coordinated and adapted bodily movement and strain, concomitant to every kind of mental process, is inconceivable, for the (psycho) motor centers in the brain have no known clairvoyant powers and therefore their function of carefully coordinating the distant muscles, *e.g.* of foot or hand, is entirely dependent on their continual reception of detailed information as to the relative tonal and contractural status of all the active parts to one another. Simple as this idea is, the immense practical importance for education has as yet hardly begun to seep into the effective minds of educators.

Some of the directions of this importance have been recently indicated by the present writer in an article on "Kinesthesia and the Intelligent Will" (*American Journal of Psychology*, vol. xxiv., No. 2, April, 1913). This little monograph contains a kinesthetic bibliography of eighty-two items. The subject is apparently now in its relative infancy as a topic of study, for it underlies many phases of life and of mind.

The direct medical applications of kinesthesia obviously lie chiefly in its conditions of defect and this mode of defect is *ataxia*, (including aphasia, apraxia, etc.). Alcoholic intoxication is obviously parakinesthesia, for example. Partial loss of the kinesthetic sense produces a greater or less degree of ataxia, or imperfect muscular adjustment and coordination such as is seen, *e.g.* in ataxic aphasia, in locomotor ataxia, and in paralytic dementia ("paresis"). The spinal afferent fibers are disturbed or destroyed in these conditions. A heightening of this sense beyond its normal state is produced by small doses of alcohol, and is felt more normally whenever, because of a lack of muscular exercise, the irritability of the muscles and their tonic balancing back and forth is increased. This condition is all too familiar to persons of sedentary habit. They feel "fidgety," and yet nothing is necessary to relieve the unpleasant feeling but vigorous muscular exercise with its accompanying aëration of the tissues and the removal of accumulated metabolic substances from the muscles and the nerve-centers. It is one of the functions of these essential afferent end-organs then to incite the individual to a normal amount of physical exercise. Thus, indirectly, one maintains the normal metabolism in the muscles (about half the mass of the body) and, by increasing the flow of lymph, invigorates and stimulates all the essential organs of the body. GEORGE V. N. DEARBORN.

Kino.—"The inspissated juice of *Pterocarpus marsupium* Roxb. (fam. *Leguminosæ*)," U. S. P. Many substances, from different parts of the earth and different plants, have, at one time or another, appeared under this name. That which is in the market at present is chiefly the product of various species of *Eucalyptus*, the official article being very scarce and dear. Recently, however, it has been reported that extensive new districts have been opened up, capable of yielding any required amount of official kino at a low price. The plant yielding the latter is a large, handsome Indian tree, whose wood is also valued for timber. In common with other species of *Pterocarpus*, this tree contains a bright-red juice, which exudes upon incisions being made in the trunk, and hardens, upon evaporation and drying, into dark, reddish-brown, brittle tears.

This, the East Indian (Malabar) kino, has been imported since the beginning of the present century, and for medical purposes has superseded the African and other varieties which were then used. It always comes in fragments or angular pieces, generaly not larger than split peas, and oftener considrably smaller; occasionally these fragments cohere together in crumbly lumps. Kino is of resinous luster and fracture, very brittle, its pieces are smooth and shining, opaque except at their edges, where they are ruby-red andtransparent; general color dark reddish-brown, sometimes almos black; odor, none; taste very astringent and sweetish. The saliva is colored bright red when kino is chewed. It is partially soluble in cold water, wholly so in boiling water and in alcohol, not in ether.

Kino is a homogeneous uncrystallizable substance, related to the tannic acids of cinchona and krameria, and more closely to catechu. Its deep red solution becomes violet on addition of a proto-, and dirty green with a persalt of iron. It appears to consist principally of *kino-tannic acid*, a red, transparent substance, soluble in alcohol and water, and capable of decomposing upon long standing in watery solution into insoluble *kino-red; kinoïn* and *catechin* may be obtained from it in small quantity, and *pyrogallic* acid, by distillation and other means.

ACTION AND USE.—Kino is an active astringent of the logwood and catechu kind, and is employed for exactly the same purposes. For subacute or chronic diarrhea or dysentery it is equally good with other

astringents, and less unpleasant than many of them. As a local application or injection, *tannic acid* is to be preferred. Kino can be given in substance, if desired —dose, gr. xv. (1.0), or in aqueous infusion; as the latter is apt to gelatinize, it should be made freshly. The official tincture (*Tincture Kino*, U. S. P.; strength $\frac{1}{10}$, with fifteen parts of glycerin) keeps better, and is the most generally useful form, but this also shows a strong tendency to gelatinize after a time.

H. H. Rusby.

Kissing-bug.—A name given to various true bugs, Hemiptera, which are supposed to sting the lips or face of man. The term has arisen largely through popular superstition and ignorance. Many of the bugs to which the term has been applied never attack man. See *Insects, Poisonous.* A. S. P.

Kissingen.—Kissingen, one of the most important and best known of the German spas, is a town of 5,500 inhabitants, beautifully situated in the valley of the Saale in Bavaria, about sixty miles from Frankfort-on-the-Main. It is 554 miles from Paris viâ Frankfort and Würzburg, and can be reached from the former city in eighteen hours. It is about 600 feet above sea-level, and is surrounded by wooded hills affording opportunity for the "Terrain-Cur." In the circular valley in which it lies are extensive pleasure grounds and promenades. The climate is mild, although there is considerable rain. The mean yearly temperature is 45.1° F. and the mean monthly is: May, 54.8° F.; June, 60.2° F.; July, 62.7° F.; August, 60.4° F.; September 54.3° F. The yearly rainfall is 25.3 inches.

The season extends from May 1 to October 1, and during this time a large number of visitors frequent this spa; in 1899, the number was 19,416, the majority of whom were Germans. The accommodations are excellent and sufficient for three or four thousand persons. The drinking-water is from well source, but said to be good, and the drainage is efficient. The springs are cold saline, the principal constituents being chloride of sodium, ferrous carbonate, sulphate of magnesium, carbonate of calcium, and free carbonic acid. Three of the springs: the Rakoczy, Pandur, and Maxbrunnen are situated in the town, and two, the Schönbornsprudel and the Sool or Salinensprudel, a short distance beyond the town limits. The Rakoczy, Pandur, and Maxbrunnen are used for drinking and the Soolsprudel and Pandur are the ones principally used for baths.

The following is the analysis (from Eulenburg) of the five springs:

Number of Grams of Solid Constituents in Each Liter of Water.

	Rakoczy.	Pandur.	Maxbrunnen.	Soolsprudel.	Schönbornsprudel.
Sodium chloride	5.822	5.207	2.316	10.554	11.719
Calcium chloride	0.286	0.241	0.376	0.250	.....
Lithium chloride	0.020	0.016	0.007	0.020	0.024
Magnesium chloride	0.303	0.211	0.108	0.330	.....
Magnesium sulphate	0.588	0.597	0.200	0.904	1.472
Calcium sulphate	0.389	6.300	0.190	0.856	0.332
Calcium carbonate	1.061	1.014	0.565	1.304	1.855
Ferrous carbonate	0.031	0.027	0.002	0.030	0.019
Calcium phosphate	0.005	0.005	0.005	0.004	0.007
Sodium nitrate	0.009	0.005	0.077	.....	.....
Sodium bromide	0.008	0.007	Trace.	0.009	0.011
Silicic acid	0.012	0.004	0.003	0.001	0.013
Organic matter, etc.	0.022	0.362	0.064	0.037	0.395
Total solids	8.556	7.996	3.913	14.299	15.847

There are three bath establishments, the property of the Government: (*a*) the Kurhaus with forty bathrooms; (*b*) the Saline with one hundred bathrooms; (*c*) the formerly called "Actienbad" with one hundred and twenty bathrooms. For bathing purposes the waters of the Sool- or the Schönbornsprudel are often rendered more stimulating by the addition of the mother liquor remaining after the extraction of the sodium chloride at the salt works. There are also carbonic-acid gas baths, mud baths, inhalation rooms, douches, massage, and a medico-mechanic institute. There are also private sanatoria for the treatment of various diseases. The Rakoczy is the best-known spring, and over four hundred thousand bottles of this water are sent abroad every year. The usual time for drinking the waters is before breakfast, from seven to nine. From two to six glasses are drunk, a fifteen minutes' walk being taken after each glass.

Kissingen waters are recommended for a variety of maladies: Hemorrhoidal troubles, constipation, catarrhal conditions of the stomach and bowels, gouty and rheumatic affections, uric-acid diathesis, bronchitis, anemia, scrofula, amenorrhea, functional nervous disorders, glycosuria, obesity, malaria, neuralgia, the headache from dysmenorrhea, cardiac diseases, and some chronic skin affections. According to Dr. Thomas More Madden, "the mother lye or concentrated saline water of the Soolensprudel, is applied with wonderful results as a local application to scrofulous glandular swellings and similar affections."

It is well to advise the visitor that here as at all other spas, the waters and baths should be used only under the direction of one of the local physicians, as otherwise harm instead of benefit might ensue. It is not only the use of the waters, but quite as much the carefully arranged daily plan of life as to diet, rest, exercise, etc., which produces favorable results.

Edward O. Otis.

Kiwisch, Franz, von Rotterau.—Born at Klattau, in Bohemia, April 30, 1814. He studied medicine at the University of Prague, and received the degree of Doctor of Medicine from that institution in 1837. A few months later he also obtained the degrees of Doctor of Surgery and Master of Obstetrics. During the years 1838–1840 he was Assistant in the Obstetrical Clinic. In 1842, after he had successfully passed the examinations required of those who propose to give instruction in midwifery, he was given charge of the Section for Diseases of Women, newly established at Prague. In 1845 he accepted an invitation to occupy the regular Chair of Obstetrics and Gynecology in the University of Würzburg. During the five years that he spent at this university he greatly increased his reputation by the satisfactory character of his teaching and by his success as an obstetrician and as a gynecologist. In 1850 he was given the regular Chair of Obstetrics and Gynecology in Prague. He held this last position, however, only a very short time, as his death (from tuberculosis of the lungs and spinal column) took place October 24, 1852.

On the authority of Pagel we may state that Kiwisch had already, before his death at the very early age of thirty-seven, attained the rank of one of the leaders of modern obstetrical science and gynecology. Of the few writings which he published during his short career the following deserve to receive special mention: "Geburtskunde," 1. und 2. Abtheil, I. Heft, Erlangen, 1851; "Vorträge über specielle Pathologie und Therapie der Krankheiten des weiblichen Geschlechtes," Prague, three volumes, 1851–1853 (both of the preceding are incomplete, and yet full of original matter); and "Beiträge zur Geburtskunde," Würzburg, 1846, 1848. A. H. B.

Klamath Hot Springs.—Siskiyou County, California. *Location.* These springs are twenty miles from Ager, a point on the Shasta Route of the Southern Pacific, 387 miles north of San Francisco and about the same distance south of Portland. Comfortable six-horse stages leave Ager daily over an exceptionally safe road. The trip may be made also by autostage. The road is open to automobiles. The climate is superb, never too hot or too cold. The elevation being 2,700 feet insures cool nights and a pure dry air, at once invigorating and with no humidity. The Springs nestle among the pines in the immense timber belt of the Siskiyou mountains. At this point the valley of the rushing Klamath River narrows and the site of the springs affords a view of mountain and river unsurpassed, while in the distance to the south can be seen Mt. Shasta, and to the north Mt. Pitt rises majestically to a height of 10,000 feet on the western shore of Upper Klamath Lake in Oregon. These wonderful views are within a few minutes walk of the hotel.

The main hotel is built of stone and is surrounded by a wide veranda. The table is supplied with wholesome food well cooked. The vegetables, fruits, dairy products, and meat are produced on the farm belonging to Klamath Hot Springs. There is fine fishing and hunting.

Near the river is the mud bath house, the sulphur bath house, and the steam room. The whole flat on which these bath houses rest is naturally heated from beneath, and numerous hot springs nearby furnish a bountiful supply of mineral water for tub baths and showers for the mud bath rooms.

The following analyses were made by William Irelan, Jr., ex-state Mineralogist, San Francisco, California, in 1896:

	Spring No. 1. Temperature 156° F. Grains per gallon.	Spring No. 2. Temperature 112° F. Grains per gallon.
Silica	4.799	3.675
Sodium sulphate	31.024	28.954
Sodium chloride	50.257	12.311
Calcium chloride	23.162	29.633
Sodium biborate	8.176	3.715
Potassium sulphate	0.630	0.181
Magnesium chloride	0.673	2.780
Iron chloride	0.535	0.241
Sodium carbonate		24.901
Lithium		Traces
Total	119.256	106.391

The waters are alkaline, saline, and sulphurous. Some of them are carbonated. The springs have gained considerable celebrity in the treatment of chronic rheumatism, gout, synovitis, malaria, liver and kidney disorders, catarrh, dyspepsia, and other ills.

There are ample accommodations for invalids and guests. The place is open throughout the year.

EMMA E. WALKER.

Klebs, Edwin.—Born at Königsberg, East Prussia, in 1834. He studied under Virchow at Würzburg, and became his assistant at Berlin in 1861, serving until 1866 when he accepted the chair of pathology at Bern. He was successively professor of pathology at Würsburg, in 1872, Prague in 1873, Zürich in 1882, and Rush Medical College, Chicago, in 1896, after which he lived in retirement at Dortmund and Bern. He numbered among his pupils many men who have made brilliant careers for themselves, particularly E. Ziegler, von Jaksch, Fischl, and Zahn. He died at his home in Bern on October 25, 1913.

Klebs was the last of the great pioneers of the bacterial theory of infection. He was in every sense a path-maker in the new fields of investigation, discovering and formulating many facts and truths which, owing to his restless temperament, he never carried to completion, allowing his contemporaries and pupils to complete the work and reap the reward. He opposed the solidist theories of Virchow, and held the theory that postmortem findings are only end results and that infectious diseases are caused by micro-organisms and their chemical products. In 1871 he worked out the bacterial investigation of the traumatic infections, seven years before Koch went over the same ground, and was the first to study the bacteriology of gunshot wounds, which he did during the Franco-Prussian War in 1870–71. In 1871 he proved that the virus of anthrax was non-filterable, and in 1873, for the first time, produced tuberculous

FIG. 3600.—Edwin Klebs.

lesions in animals by feeding them with Perlsucht milk. In 1876 he succeeded in producing endocarditis by mechanical means combined with general infection. In 1881 he found the typhoid bacillus, before Eberth had demonstrated it to the world. The discovery of the diphtheria bacillus (Klebs-Loeffler), by which he is best known, occurred in 1883. Loeffler's name is always associated with that of Klebs in this discovery. In 1900 he treated tuberculosis with the bacilli of cold-blooded animals, and he was one of the first to advance the theory of the parasitic cause of syphilis. His most important writings were a short discourse on medical history delivered at Bern in 1868, his *Handbook on Pathological Anatomy* published in 1869–76, and his larger *Allgemeine Pathologie* produced in 1887–89.

He was founder and co-editor of the *Correspondenzblatt für schweizer Aerzte* in 1871, and in 1876 of the *Prager medicinische Wochenschrift.* He was also, with Naunyn and Buchheim, in 1872 a founder and co-editor of the *Archiv für experimentelle Pathologie und Pharmakologie.*

E. L. J.

Knapp, Hermann.—Born at Danborn, Prussia, March 17, 1832. He received the degree of Doctor of Medicine from the University of Giessen, in 1854. He settled in Heidelberg, and was appointed, first (1860) Lecturer in the University, and then (1865) Profesor of Ophthalmology. In 1868 he resigned his professorship and settled in New York. In 1869 he founded the New York Ophthalmic and Aural Institute, a hospital and school for the treatment and study of eye and ear diseases; and at about the same time he began the publication, in German and in English, of the *Archives of Ophthalmology and Otology.* In 1876 he was appointed Lecturer on Eye and Ear Diseases in the Spring Faculty of the College of Physicians

and Surgeons, New York City; and in 1888, upon the death of Dr. C. R. Agnew, who had up to that time held the chair, he was made full Professor of Ophthalmology. His death occurred in 1908.

Dr. Knapp was for many years one of the most industrious workers in the field of ophthalmology. He conducted a large and constantly growing private practice; he was assiduous in his attention to the work of his private hospital; he gave courses of instruction in ophthalmology to private classes; and he conducted

Fig. 3601.—Hermann Knapp.

his special journal in an admirably thorough and acceptable manner. Long before he died he had secured for himself a world-wide reputation as a skilful ophthalmic surgeon of vast experience.

A. H. B.

Knee-jerk.—See *Reflexes*.

Knee-Joint.—(Articulatio genu, BNA; Articulation du genou, *Fr.*; Kniegelenk, *Ger.*) The articulation between the thigh and the leg, formed by the adaptation of the distal end of the femur to the proximal end of the tibia and the posterior surface of the patella. It is the most complicated and extensive joint in the body, with surfaces necessarily large to support the superincumbent weight, a great extent of synovial membrane that predisposes it to inflammation, and an exposed situation that renders it liable to injury. On the other hand, though its articular surfaces are only in partial contact, the strength of the surrounding muscles, ligaments and fascia is such that it is able to withstand the leverage of the two longest bones in the body, and dislocation is rare.

Unlike the elbow, the corresponding joint of the thoracic limb, the lateral bone of the next segment (the fibula) is excluded from the articulation. True pronation and supination, so marked a feature of the radiohumeral joint, is therefore impossible. Stability is much increased by this exclusion which is effected by the rapid growth of the large proximal epiphysis of the tibia cutting off the fibula from its primitive share in the articulation preserved throughout life by most mammals. This may reasonably be considered an adaptation to the erect position characteristic of man.

Flexion and extension being the main movements of the articulation, it is usually classed as a ginglymus or hinge-joint. The tibia may, however, slide back and forth on the femoral condyles, and, during partial flexion, may rotate slightly about a vertical axis. A more accurate characterization would therefore be to call it a ginglymoid joint or ginglymoarthrosis.

Topography and Relations.—In front the joint is closed by the tendon of the quadriceps femoris coming down from the thigh, embracing the sesamoid patella and continuing downward as the patellar ligament to the tuberosity of the tibia. The skin over the patella is fairly thick and sometimes rugous, especially in slaters, miners, and others who work while resting on the knees. The subcutaneous fascia is loosely laminated in front, permitting considerable mobility of the skin. Several bursæ occur in this region. Even in fat people there is not much adipose tissue here, so that their knees appear proportionately small. Below there lies on each side of the patellar ligament a circumscribed mass of fat that may impart an impulse like fluctuation when palpated.

At the sides the joint capsule is covered only by skin that readily reveals the subjacent structures and movements. In extension the medial border of the patella is more prominent than the lateral one, exceeding also the medial condyle of the tibia. The reverse occurs on the lateral aspect. When extended, a marked depression is seen on each side of the patella. In semiflexion a triangular depression that indicates the position of the joint is seen on the medial side between the border of the patella, the condyle of the femur and the proximal edge of the condyle of the tibia. The interarticular line between the tibia and the femur may be felt here a little above the apex of the patella in extension and level with it when the knee is slightly flexed. The great saphenous vein and the saphenous nerve are found on the medial side, and laterally the iliotibial band of the fascia lata passes to a tubercle that may be felt on the margin of the lateral condyle of the tibia, between the apex of the patella and the head of the fibula.

Posteriorly the joint is covered by the boundaries and contents of the popliteal fossa. The skin is quite movable, delicate and smooth, rich in sudoriparous and sebaceous glands. Medicaments placed on the surface are readily absorbed. The transverse lines of flexion often seen here are some distance above the articulation and do not serve as a guide to the joint. A dense sheet derived from the fascia lata stretches across the fossa and when the knee is extended obscures the subjacent structures and quite obliterates the hollow that occurs when the knee is flexed. It confines fluids originating in the fossa or extending into it from above. The tendons of muscles above and below the knee circumscribe the fossa, bounding a lozenge-shaped space composed of a proximal or femoral triangle and a distal or tibial one much the smaller of the two. The tendons of the femoral triangle are those of the semitendinosus and the semimembranosus medially and the biceps laterally. These embrace the tendons bounding the tibial triangle derived from the two heads of the gastrocnemius. Within this lozenge-shaped space the joint is clothed with a soft, fatty tissue in which are embedded the popliteal vessels, the tibial and common peroneal nerves, the termination of the small saphenous vein, the terminal branches of the obturator and posterior femoral cutaneous nerves and a few lymphatic glands. The popliteal artery lies next the joint capsule, the vein is next and the tibial nerve is most superficial. These structures lie nearly in the long diagonal of the lozenge. The common peroneal nerve is close to the tendon of the biceps at the lateral border of the femoral triangle. The short saphenous vein enters at the apex of the tibial triangle and joins the popliteal vein.

Articular Surfaces.—At the distal end of the femur (Fig. 3602) the articular surface is divided by faint grooves into three parts, of which the medial and lateral ones, situated on the condyles, are for articulation with the tibia, the intermediate or intercondylar one (facies patellaris, BNA) is for the patella. The condylar surfaces follow the curve of a spiral, that is to say, the radius of curvature decreases from before backward. Considering the condyles as wheels or rollers, it will be observed that they are obliquely inclined to each other, diverging distally and backward. Their surfaces also curve slightly from side to side. The cartilaginous covering is from 2.6 to 3.2 millimeters thick. The intercondylar or patellar surface is troch-

lear or saddle shaped, that is to say, it is curved from above downward, continuing approximately the curvature of the posterior portion of the condyles, and concave from side to side. It ascends further on the lateral than on the medial side and the lateral edge is somewhat more prominent. In the central portion the cartilage is 3.5 millimeters thick.

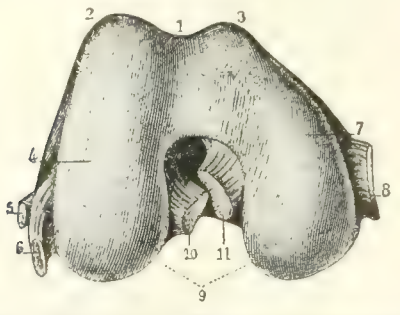

FIG. 3602.—Distal Surface of Femur and Ligaments of Knee-joint. (Sappey). 1, Intercondylar or patellar surface; 2, lateral edge; 3, medial edge, less elevated than the other; 4, lateral condyle; 5, fibular collateral ligament, cut; 6, cut tendon of popliteus muscle, directed downward and laterally and covered by the fibular collateral ligament; 7, medial condyle; 8, tibial collateral ligament, cut; 9, intercondyloid fossa; 10, cut end of the anterior cruciate ligament inserted upon the posterior part of the deep surface of the lateral condyle; 11, cut end of the posterior cruciate ligament inserted upon the anterior part of the deep surface of the medial condyle.

The articular surface of the patella is adapted to the shape of the femoral surface on which it glides, being provided with a vertical median ridge that fits into the trochlear groove. The cartilage on this ridge is thicker than on any other articular surface in the body, attaining a thickness of from 5.4 to 6.4 millimeters. On either side of this ridge are lateral facets that impinge against the condyles. A narrow portion of the medial facet is usually marked by contact with the border of the medial condyle in extreme flexion. There may usually be made out on either side of the median ridge

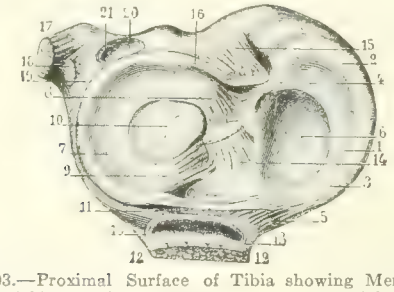

FIG. 3603.—Proximal Surface of Tibia showing Menisci and Ligaments of Knee-joint. (Sappey.) 1, 2, 3, Medial meniscus; 4, its attachment behind the intercondyloid eminence; 5, its anterior attachment; 6, that part of the medial glenoid cavity not covered by the meniscus; 7, lateral meniscus; 8, its anterior attachment in front of the intercondyloid eminence; 9, its posterior attachment; 10, part of lateral glenoid cavity not covered by meniscus; 11, transverse ligament; 12, patellar ligament cut; 13, bursa infrapatellaris profunda, cut; 14, tibial insertion of the anterior cruciate ligament; 15, of the posterior cruciate ligament; 16, bundle of fibers from lateral meniscus; 17, tendon of biceps, cut; 18, fibular collateral ligament, cut; 19, groove for tendon of popliteus; 20, popliteal bursa; 21, orifice occasionally found by which the tibiofibular articulation communicates with the knee-joint.

three additional impressions corresponding to various degrees of flexion. These vary considerably in races that habitually sit with the knees tightly bent.

The proximal surface of the tibia (Fig. 3603) is not always quite horizontal, being often inclined slightly downward and backward, differing in individuals and at different ages. This appears to be a persistence of the fetal condition caused by the bent position of the knees *in utero*. It is marked in young infants and decreases as the child learns to walk. It is more noticeable in savages and in persons who walk habitually with the knees slightly bent.

This surface presents two articular facets with an hour-glass shaped interval between. Upon these facets rest the femoral condyles and corresponding to them the medial is larger, oval, with its long axis anteroposterior, while the lateral one is smaller and rounder. The medial one is also concave both from before backward and from side to side, while the lateral one, slightly concave from side to side, is slightly convex from before backward when covered by cartilage which is here 4 to 5 millimeters thick in the middle, thinning to 2 millimeters at the edge. On the hour-glass surface eminences and depressions occur for the attachment of the cruciate ligaments and the extremities of the C-shaped menisci that surround the articular facets.

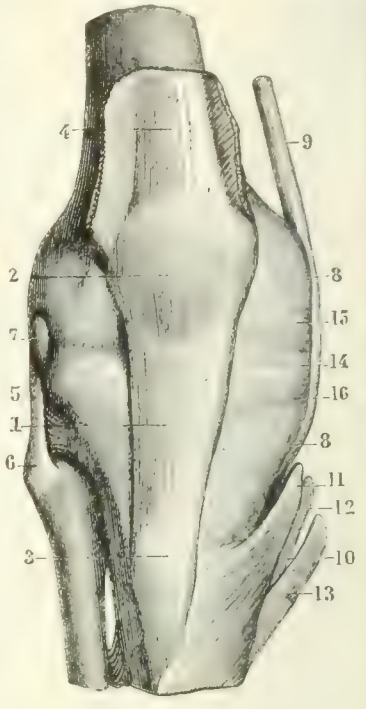

FIG. 3604.—Anterior Surface of the Knee-joint, (Sappey.) 1, Ligamentum patellæ; 2, its expansion over the patella; 3, its insertion upon the tibia; 4, tendon of the quadriceps extensor femoris; 5, fibular collateral ligament; 6, its insertion upon the head of the fibula; 7, tendon of the popliteus; 8, tibial collateral ligament; 9, tendon of the adductor magnus; 10, fascial expansion of the medial hamstring tendons (*patte d'oie*); 11, tendon of the sartorius; 12, tendon of the gracilis; 13, tendon of the semitendinosus; 14, medial meniscus; 15, the proximal synovial cavity of the joint; 16, distal synovial cavity, separated from the preceding by the meniscus.

These menisci (semilunar fibrocartilages, C-cartilages) are strips of dense fibrous tissue interspersed with elastic fibers and cartilage cells that adapt the nearly flat surfaces of the tibia to the rounded ends of the femoral condyles and make the joint more secure. Their breadth is not sufficient to cover the whole of the articular surfaces and they are thick and rounded at the periphery where they are attached to the capsule and associated structures and are beveled to a sharp internal edge. The upper surface is concave, adapting itself to the curvature of the condyles, the lower surface is nearly flat. Their pointed ends or cornua are attached to the interspace between the articular surfaces. Their elasticity and mobility are such that they readily adapt themselves to slight changes of position of the condyles. Unlike hyaline cartilage, they are abundantly supplied with vessels and nerves. The medial meniscus is C-shaped, comprising from one-third to three-fourths of an elliptical curve, its cornua embracing those of the lateral meniscus which is O-shaped, forming nearly a complete circle. Between the two anterior cornua is the tibial insertion of the anterior cruciate ligament, while the posterior cruciate ligament is situated behind the posterior cornua, receiving a bundle of fibers from the

lateral meniscus.* A variable, rounded band (transverse ligament) connects the anterior margins of the two menisci.

Articular Capsule. The joint is surrounded by a thin, fibrous investment that forms a loose and capacious sleeve, so inextricably blended with strengthening expansions from muscles, tendons and fasciæ that it is difficult always to demonstrate its separate continuity. It extends farther up in front, where it reaches from ½ to 2 centimeters above the articular cartilage, than upon the sides and behind, where it leaves the epicondyles and the adductor tubercle free and is attached to the intercondyloid line. On the tibia it is attached a little below the margin of the articular cartilage. The line of union of the distal epiphysis of the femur is partly within the capsule and partly without it, that of the proximal epiphysis of the tibia is wholly intracapsular.

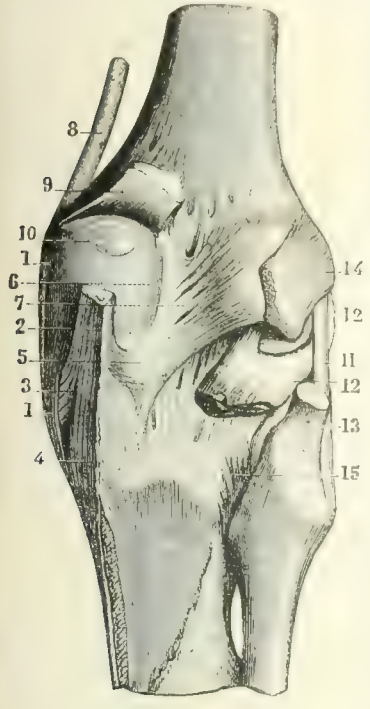

Fig. 3605.—Posterior Surface of the Knee-joint. (Sappey.) 1, 1, Tibial collateral ligament; 2, tendon of the semimembranosus; 3, its anterior or reflected portion; 4, its middle portion attached to the posterior part of the medial condyle of the tibia. From this middle portion two expansions extend—one reaches the lower part of the medial condyle, the other is continuous with the aponeurosis of the popliteus; 5, posterior portion of the tendon of the semi-membranosus. It forms a posterior ligament (ligamentum popliteum obliquum) directed upward and outward, to be inserted upon the lateral condyle; 6, 7, fibres of this tendon directed vertically upward; 8, tendon of the adductor magnus; 9, tendon of the medial head of the gastrocnemius; 10, orifice often found in the fibrous capsule over the medial condyle; 11, fibular collateral ligament; 12, tendon of the popliteus; 13, tendon of the biceps; 14, tendon of the lateral head of the gastrocnemius. 15, the posterior proximal tibiofibular ligament.

The strong tendon of the quadriceps together with the patella and its ligament form an efficient protection in front, constituting an anterior ligament for the joint (Fig. 3604). Expansions from the vasti muscles and from the fascia lata blend with this on either side, forming what are known as the Retinacula patellæ. The patella itself so penetrates the capsule that its articular surface presents free within it.

Posteriorly (Fig. 3605) the capsule is strongly reinforced by an expansion from the tendon of the semimembranosus which is reflected obliquely toward the lateral condyle of the femur, the origins of the plantaris and the lateral head of the gastrocnemius, forming what may be considered a posterior ligament (Ligamentum popliteum obliquum, BNA: Ligamentum posticum Winslowi). On the lateral portion of the posterior surface a variable band is found closely connected with the tendon of origin of the popliteus muscle, arching from the lateral epicondyle under the oblique ligament and losing itself on the capsule. This is the so-called arcuate ligament. An inconstant offset from it, passing to the head of the fibula, was formerly called the short external lateral ligament, but is known in the BNA as the retinaculum of the arcuate ligament. Between the bands here mentioned the continuity of the capsule is interrupted by numerous intrusions of fatty tissue, and is pierced by vessels and nerves.

On both sides of the joint collateral ligaments afford efficient protection (Figs. 3606 and 3607). The fibular collateral (long external lateral ligament) is a strong rounded cord usually separated from the capsule by fatty tissue, attached above to the lateral epicondyle of the femur, distal to the lateral in-

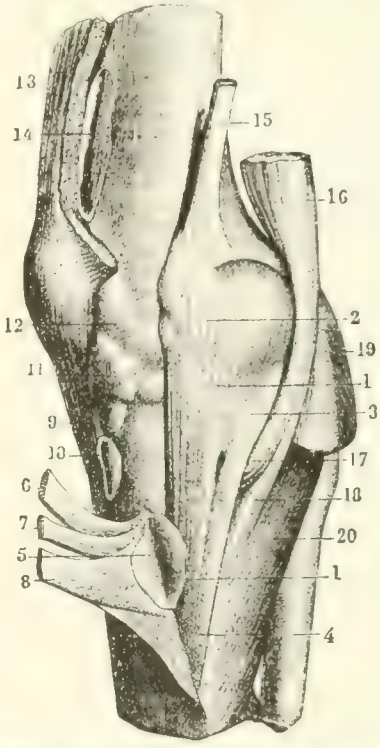

Fig. 3606. View of the Knee-joint from the Medial Side. (Sappey.) 1, 1, Tibial collateral ligament; 2, its insertion upon the medial epicondyle; 3, its insertion upon the medial meniscus; 4, its insertion upon the proximal end of the medial surface of the tibia; 5, bursa anserina; 6, tendon of the sartorius; 7, tendon of the gracilis; 8, tendon of the semitendinosus; 9, ligamentum patellæ; 10, bursa subpatellaris; 11, adipose tissue near its proximal part; 12, proximal synovial cavity; 13, tendon of the quadriceps extensor; 14, bursa suprapatellaris; 15, tendon of the adductor longus; 16, 17, tendon of the semimembranosus; 18, its middle portion; 19, tendon of the medial head of the gastrocnemius; 20, the popliteus.

termuscular septum, and inserted below on the lateral edge of the head of the fibula. It is supposed by Sutton and others to be a detached portion of the tendon of the peroneus longus that formerly arose from the femoral condyle, a permanent condition in many animals. Its proximal part crosses over the tendon of the popliteus, its middle is against the lateral meniscus and its distal portion is embraced by the tendon of the biceps femoris which here divides into two parts, connected with the ligament by loose connective tissue. The ligament is tense when the knee is extended, loose when the knee is flexed.

The tibial collateral (internal lateral ligament) is a broad, flattened band, closely united to the capsule.

* This is not mentioned in the BNA. By Fick it is called the Radix obliqua menisci lateralis (Weitbrecht). In the recent English edition of Gray's Anatomy, edited by Howden, it is called the Ligament of Wrisberg. Fick says that Weitbrecht described it in 1742, Wrisberg not until 1780. Both Toldt and Rauber call it the Ligamentum menisci lateralis (Roberti).

It arises from the medial condyle of the femur, just below the adductor tubercle, and descending, divides into a long, anterior, superficial portion and a short, posterior, deeper one. The superficial slip is inserted on the medial surface of the tibia and is overlaid by the insertion of the medial hamstring tendons; the deeper slip inclines backward and is inserted on the medial meniscus and on the head of the tibia, above the groove for the semimembranosus. In the fetus this ligament is plainly seen to be a continuation of the tendon of the adductor magnus which later on withdraws its distal insertion to the adductor tubercle, leaving the abandoned portion to become a ligament of the joint.

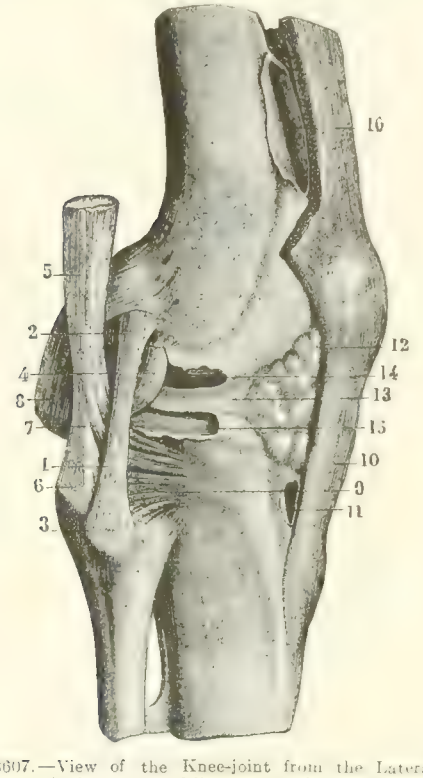

Fig. 3607.—View of the Knee-joint from the Lateral Side. (Sappey.) 1, Fibular collateral ligament; 2, its attachment to the lateral condyle; 3, its attachment to the lateral part of the head of the fibula; 4, tendon of the popliteus; 5, tendon of the biceps; 6, its attachment to the apex of the head of the fibula; 7, the anterior or reflected part of this tendon, passing under the fibular collateral ligament, to be inserted upon the medial condyle of the tibia above the anterior ligament of the proximal tibiofibular articulation; 8, tendon of the lateral head of the gastrocnemius; 9, anterior ligament of the proximal tibiofibular articulation; 10, ligamentum patellæ; 11, bursa subpatellaris; 12, collection of fat which fills the anterior part of the inter-condyloid fossa. On each side it passes beyond the ligamentum patellæ; 13, lateral meniscus; 14, the proximal synovial cavity, opened to show how it terminates upon the proximal edge of the meniscus; 15, distal synovial cavity also opened to show its relation to the same meniscus; 16, bursa suprapatellaris.

Intraarticular Structures.—On examining attentively the interior of the joint it seems clear that we ought to regard it as a fusion of three articulations: one between each condyle of the femur and the tibia, one between the patella and the femur. This is more evident in some other animals, but there are in the human species sufficient remains of primitive structures to amply confirm this view. These are the cruciate ligaments and the patellar and alar synovial folds.

The cruciate ligaments, so-called from their intercrossing like an X, are two strong bands situated in the middle of the joint, passing respectively from the anterior condyloid depression of the tibia to the medial condyle of the femur (anterior cruciate ligament) and from the posterior condyloid fossa to the lateral condyle (posterior cruciate). They are distinct from each other with separate synovial coverings. The anterior ligament is tense in a position of extension, the posterior in one of flexion.

The synovial membrane of the joint cavity is heavily charged with fat which pads out the intervals between the bones and between the bones and the adjacent structures. A well-marked collection of this sort (infrapatellar pad) is found in the triangular space between the patella, the tibia and the femoral condyles. From it passes a fold of the membrane (plica synovialis patellaris, BNA; patellar synovial fold, ligamentum mucosum) that appears to represent a primitive septum partially dividing the joint. It is attached by its apex to the intercondyloid notch, and its edges are known as the alar synovial folds (plicæ alares, BNA; ligamenta alaria). The synovial membrane clothes both upper and lower surfaces of the menisci, extends upward a variable distance under the extensor tendon and usually communicates there with a large bursa (B. suprapatellaris). Another constant communication is with the bursa under the tendon of the popliteus (Fig. 3603), and from this there is an occasional diverticulum connecting with the proximal tibiofibular articulation. A third communication is with the large bursa under the internal head of the gastrocnemius. Many other bursæ are found near the joint (see article on *Bursæ*, vol. ii.), and some of them may occasionally connect, so that extreme care is always required in operations in this region, lest the opening of one of these sacs should involve the joint cavity.

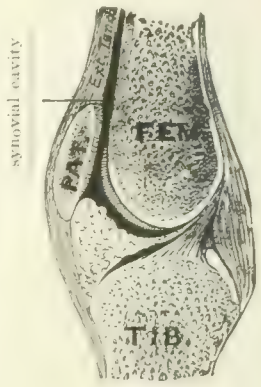

Fig. 3608.—Sagittal Section of the Knee-joint.

The movements of the patella are not only gliding, but slightly rolling or coaptative. The bone is adapted to the shape of the patellar surface between the condyles by a ridge which divides it into two unequal, lateral portions. Each of these is again divided into facets, so that, taken from above downward, the contact of the bone with the femur is but slight, especially during flexion. It is this circumstance that causes the frequent fracture of the patella by muscular action. It forms a wedge-like body, in contact with the articular surface only by a narrow edge, and the tendinous attachments are so arranged as to pull at right angles to each other directly over this edge. Any sudden jerk in this position has the same effect upon the bone as a sudden shock upon a stick over the edge of a table. It is not strange, therefore, that it is more frequently broken by muscular action than any other bone in the body.

Atmospheric pressure is not without effect on the joint. In conditions of health it holds the patella firmly down and prevents its dislocation. In cases of opening the joint, or where there is effusion, the bone becomes much more movable laterally, and may be spontaneously dislocated.

The movement of the tibia upon the femur is such that, with flexion and extension, a slight degree of rotation always takes place. This is due to the peculiar shape of the condyles above mentioned, which permits a considerable amount of lateral motion. This is most free in the semi-flexed state, and may then amount to forty degrees. It is sometimes called pronation

(which turns the toes in), and supination (turning them out), but is not produced by the same mechanism as the motions of the same name in the elbow-joint. The movements of flexion and extension do not exceed an arc of 160 degrees.

The joint is copiously supplied with vessels from the femoral, popliteal, and anterior tibial arteries. The nerves are from both the sacral and the lumbar plexuses, the former through the tibial and common peroneal, the latter through the femoral and geniculate branch of the obturator. It is interesting to note that interference with these nerves at any part of their course, or centrally, is followed by pain in the knee. The phenomenon known as "hysterical knee-joint," in which there is pain accompanied by no lesion in the joint proper, is usually thus explained.

FRANK BAKER.

Knock-knee.—*Synonyms:* Genu Valgum, In-knee. In the erect posture the femora whose upper extremities are separated by the pelvis, incline slightly inward to the knee, forming angles at this point opening outward of about one-hundred and seventy-two degrees. The angle varies with the breadth of the pelvis, and in adult females, what may be called normal genu valgum, is often present. In compensation for the inclination of the femur the internal condyle is slightly longer than the external; thus the plane of the knee-joint is horizontal.

If the inward projection of the knees is increased to deformity the tibiæ are no longer perpendicular, and in the erect posture the feet are separated when the knees are in contact. In other words, the knees are in contact when the feet are in the proper attitude for walking, hence the term knock-knee.

In the slighter grades of knock-knee, due in great part to laxity of the ligaments, the deformity appears

FIG. 3609.—Typical Rachitic Knock-knees.

only in the upright posture, but in more marked cases it persists when the weight of the body is removed because it is caused by distortion of the bones.

As has been stated, in the normal subject the inward inclination of the femur is compensated by the greater length of the internal condyle; and in the deformity of knock-knee the plane of the knee-joint is still preserved by what is apparently a further elongation of this part of the bone. In fact, it was thought at one time that the cause of knock-knee was hypertrophy of the internal condyle, but it is now generally accepted that the apparent lengthening is caused by deformity of the lower extremity of the shaft of the femur. This is bent with the convexity inward, so that the epiphyseal line has an increased obliquity. Thus it is apparent that the internal condyle is lowered by a deformity of the shaft of the femur and not by a change in the epiphysis itself.

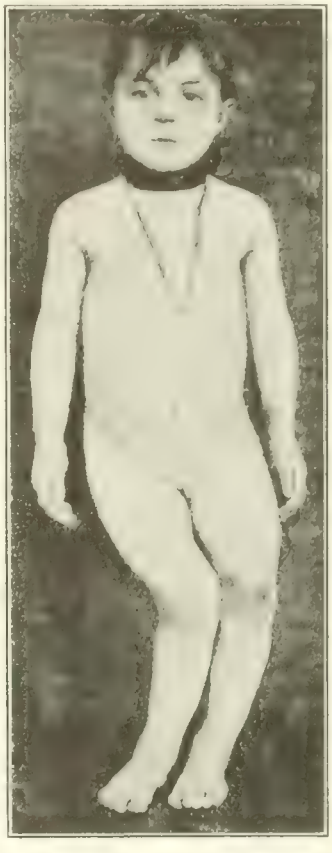

FIG. 3610.—Knock-knee and Bow-leg.

In most instances there is a similar, although usually slighter, deformity of the upper extremity of the tibia, so that when the bone is placed in the perpendicular position its internal condylar surface is higher than the external. In rather unusual cases the deformity may be confined practically to the tibia.

In addition to these direct deformities there is a more or less constant change in the relation of the two bones, the femur is rotated inward and the tibia is rotated outward. In some instances there is a certain degree of overextension at the knee; this is more often observed in the adolescent type, which is more directly dependent upon laxity of ligaments. In the ordinary form of rachitic knock-knee in childhood, however, the typical attitude is one of slight flexion of the knees, and in well-marked cases there may be limitation of the range of extension at the knee and at the hip also.

The deformity of knock-knee is most marked when the limb is fully extended, because the shortened tissues on the outer aspect of the joint become tense and because the outward rotation of the tibia is increased. As the leg is flexed the deformity lessens, and in complete flexion it disappears. This is explained by the fact that the posterior surface of the condyles is not affected by the deformity of the shaft, while the relaxation of the ligaments and the outward rotation of the femora permit the tibiæ to become parallel with one another. Thus slight flexion at the knees, which lessens the deformity, is the attitude which is often unconsciously assumed by patients.

The outward inclination of the leg increases the strain upon the foot and tends to induce the attitude of valgus, and rachitic knock-knee in the progressive stage is almost always accompanied by flat-foot. After recovery from the local or constitutional weakness the efforts of the patient to restrain the abnormal separation of the feet may induce the opposite attitude of inversion. In fact, extreme knock-knee is usually accompanied by a slight degree of fixed varus,

and in the mildest type of knock-knee this compensatory effect of nature, shown by the so-called pigeon-toed walk, may be the most noticeable symptom of the deformity.

As a rule, genu valgum is bilateral, but not infrequently it is unilateral, and again unilateral knock-knee may be accompanied by outward bowing of its fellow.

In the slighter degrees of rachitic deformity outward bowing of the tibia may accompany inward inclination at the knee. Thus, in-knee and bow-leg may be present in the same limb. In the marked distortions of the lower extremity that are the result of rachitis the bones may be bent and twisted in various directions. For example, the femora may be bent forward and outward above, and inward and backward below; the tibiæ may be bent inward above and outward and forward below. This is sometimes called "cork-screw" distortion, of which the outward expression is knock-knee.

In the more extreme deformities caused by rachitis the shape as well as the contour of the bones is changed. For example, the internal border of the tibia may become very prominent at its upper extremity and project beneath the skin like an exostosis. A change in the contour of the fibula accompanies and corresponds to that of the tibia, but it is, as a rule, less marked.

Pathology.—In rachitic knock-knee, the changes in the bones and in the epiphyseal cartilages are characteristic of that disease. In the milder degrees of deformity, however, aside from the change in shape and the accompanying transformation of the internal structure of the bones, there is little that is noteworthy. The tissues on the internal aspect are relaxed, those on the outer side, the lateral ligaments, the capsule, and the biceps muscle, are contracted. Within the joint slight changes in the articulating surfaces of the bones and evidences of chronic irritation of the synovial membrane are sometimes seen.

Symptoms.—The deformity and the effects of the deformity on the gait and attitude are the most important symptoms, as they are of other distortions of similar origin. The gait of the patient with well-marked genu valgum is peculiarly awkward and shambling. The knees "interfere" and must be assisted, as it were, in the effort to pass one another in walking. In the slighter cases the thigh is abducted and rotated outward at the moment of passing its fellow, the movement being then reversed, as it, in its turn, supports the weight; but in the more severe type this voluntary effort of the muscles of the leg is not sufficient, and the body is swayed from side to side, the legs being alternately swung outward and lifted past one another.

In unilateral knock-knee, the leg being shortened by the distortion, a limp replaces the swaying gait.

Etiology.—Knock-knee is a deformity characteristic of weakness. The distortion is an exaggeration of the attitude of rest, and it may be assumed that in many instances the more or less constant assumption of the passive attitude, induced probably by weakness of the supporting muscles, is the cause of the deformity, the changes in the contour and in the internal structure of the bones being simply adaptations to the habitual posture. In the great majority of the cases the direct cause of the distortion is rachitis, and it develops therefore when the erect posture is assumed. In such instances a common attitude of the weak child is slight flexion at the three joints of the lower extremity, the knees being in contact with one another. To the habitual assumption of a somewhat similar attitude is ascribed the frequency of knock-knee among adolescent and adult bakers. It is probable also that postures assumed by the weak child in sitting and creeping before it begins to walk may determine the character of the subsequent distortion when weight is thrown upon the limb. One of the explanations of combined bow-leg and knock-knee is that the child has been habitually held upon the mother's arm in a manner to induce the deformity by direct pressure. Typical knock-knee is a deformity of childhood, but under favoring circumstances it may develop in adolescence. It is probable, however, that in many of these cases a slight degree of deformity was present in childhood, which later developed to noticeable distortion. Genu valgum may be induced directly by traumatism or by disease, and it may be a secondary or compensatory effect of deformity at the hip- or ankle-joint. These causes are, however, relatively insignificant.

Treatment.—Treatment of the deformity may be characterized as expectant, mechanical, and operative. During the expectant treatment the cause of the deformity, in most instances rachitis, should receive proper medicinal and dietetic treatment. If possible the direct exciting causes of the deformity should be removed; that is to say, the improper attitudes or the predisposing occupations should be discontinued.

In the slighter degrees of deformity, more particularly in weak or rachitic children, the limbs should be vigorously massaged at morning and at night, and forcibly straightened. The latter procedure is conducted as follows: The patient is seated in a chair; the leg is fully extended in order to make the deformity as extreme as possible; one hand then clasps the knee, the palm lying against its inner aspect; the calf is grasped firmly, and the limb is gently straightened over the fulcrum formed by the palm of the hand. This manipulation should be continued with gradually increasing force, although not to the extent of causing pain, for ten minutes, at least twice a day, and oftener if possible. This type of knock-knee, which is in itself an indication of weakness, is usually accompanied by flat-foot; thus the soles of the shoes should be made thicker on the inner border, as is described in the treatment of weak foot. If possible the patient should be instructed to walk with the feet parallel with one another, and tip-toe or other exercises in which the limbs are fully extended should be encouraged. A careful record of the deformity should be kept during this tentative treatment, and if there is some improvement one is justified in delaying more radical measure.

There is, practically speaking, no spontaneous outgrowth of knock-knee deformity, such as is not infrequently observed in the opposite distortion of bow-leg.

Treatment by Braces.—The most efficient brace in the treatment of genu valgum is the simple straight steel bar or splint extending from the trochanter to the heel of the shoe, without joint at the knee. The greater efficacy of the rigid bar as compared with the jointed brace is explained by the fact that the rectifying force acts constantly when the joint is fixed, preventing the attitude of flexion so characteristic of the deformity.

The simplest and cheapest brace is that of Thomas (Fig. 3611), which consists of a light steel bar provided with a pad at its upper end for pressure against the trochanter, while the lower rounded extremity is turned inward at a right angle, to pass through the heel of the shoe. The knee is fixed by a posterior bar attached to a thigh and calf band, as illustrated in the figure. When the brace is applied the knee is drawn backward and outward, and is attached firmly to the brace by a roller bandage.

In the more extreme cases, in which the knees and thighs are habitually flexed, the addition of a pelvic band attached to the uprights by a free joint at the hips, adds to the comfort and efficiency of the apparatus, as the attitude of the feet can be regulated by twisting the uprights slightly, or the pelvic band may be divided, the two halves being attached to one an-

other by straps and buckles (Fig. 3612). The uprights may be bent somewhat inward at first, and as the legs become straighter they are straightened and finally bent outward to allow for the overcorrection of the deformity. Twice a day the braces should be removed to allow massage, manipulation, and voluntary exercises of the legs. In most cases the braces are not employed at night, although the rectification of the deformity may be hastened by their constant use. It is of course evident that mechanical treatment would be more effective if the child were not allowed to stand; as a rule, however, the brace must be employed as an ambulatory appliance.

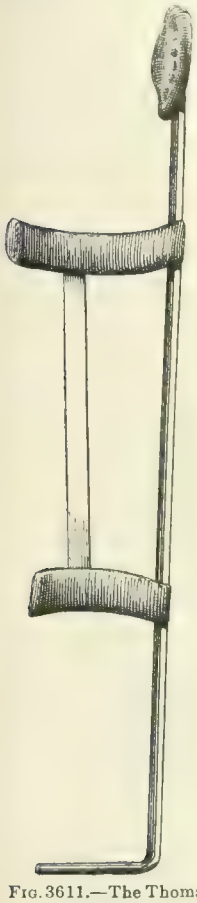

Fig. 3611.—The Thomas Knock-knee Brace.

If the deformity is unilateral so that a brace is required for one leg only, the other shoe should be raised by a cork sole about three-quarters of an inch in thickness to make walking easier. Children soon become accustomed to the braces and walk easily in spite of the absence of joints.

The duration of the brace treatment depends of course upon the degree of the deformity and the age of the child; from six months to a year is the ordinary period. Cure is assured by the gradual adaptation of the parts to the new static conditions, and by the transformation of the internal structure of the bone which accompanies the rectification of the deformity. When the braces are discarded attention should be paid to the attitudes, and exercises and massage should be continued with the aim of strengthening the muscles of the limb.

If the bones are very flexible, as in deformity due directly to rachitis in young children, it may be corrected rapidly by the repeated application of plaster bandages. This method is not often employed except in dispensary practice.

Operative Treatment.—Immediate correction of deformity, when it is at all marked, is as a rule indicated after the age of three or four years. For although it may be possible to correct the distortion by mechanical treatment in cases far beyond this limit of age, yet the time required and the incidental discomfort exclude it from consideration in all but very exceptional cases. Immediate correction of the deformity may be attained by osteotomy or by osteoclasis.

Osteotomy.—The so-called subcutaneous osteotomy is the operation of choice. The limb having been prepared in the usual manner is semi-flexed and the inner surface of the knee is placed on a sand bag. With the fingers the femur is firmly grasped just above the condyles so that the size and position may be accurately determined, and a sharp osteotome about the size of a lead pencil is forced, with its cutting edge parallel with the axis of the leg, down to the bone, at a point about one and a half inches above the tuberosity of the external condyle. While it is held firmly in position against the bone, it is turned to the transverse direction and is then driven through the cortex. When it enters the medullary canal, as is made evident by the lessened resistance, it is partly withdrawn and moved slightly to one side and the other and driven through the cortical substance, until with gentle force the bone may be fractured. The osteotome is then withdrawn, the minute wound is covered with a pad of dry gauze, or, if the oozing be profuse, it may be closed with a catgut suture. The deformity is then overcorrected by bending the cortex on the inner side and opening a wedge-shaped gap in the bone, sufficient to make the patient somewhat bow-legged when the plaster bandage is applied. If the deformity is double, both limbs are operated upon, and, in order to assure better fixation, it is the rule to apply a spica bandage, double or single as the case may be, which includes the foot as well.

The plaster support is continued for from four to six weeks, and it is then usually supplemented by a brace. This may be worn with advantage for several months, because of the laxity of the ligaments of the knee-joint which is usually present in this type of deformity of rachitic origin. In less marked cases, particularly those in older subjects, the support is unnecessary. Massage and exercises during the stage of recovery should be employed if possible.

In the more extreme cases of general rachitic deformity of the lower extremity osteotomy below the knee may be required also, and there are cases in which the knock-knee is caused directly by the inward bowing of the tibia which alone requires correction. As a rule when the tibia is divided the fibula may be bent or broken by manual force. In such cases it is better to perform the second operation at a later time

Fig. 3612.—The Modified Thomas Brace with Pelvic Band, showing Overcorrection of Deformity.

in order that the effect of the first procedure may be observed. In certain extreme cases cuneiform osteotomy of the tibia may be indicated in preference to simple division.

Osteoclasis.—Osteoclasis by means of the Grattan osteoclast is, from the standpoint of the result, an equally efficient treatment. With this instrument the bone may be broken above the condyles at the desired point. It may be employed in preference to osteotomy in rachitic cases in which correction of both thigh and leg is performed at one sitting.

The adolescent type of genu valgum is not often extreme, and as a rule the distortion of the bone is comparatively slight, the deformity being exaggerated by laxity of ligaments and by the habitual attitude. In the more chronic cases osteotomy above the condyles may be performed in the manner described, but in Berlin and Vienna where the deformity is more common than in New York, other procedures are often employed.

One method is that of Wolff, who by means of the "Etappen Verband," gradually corrects the deformity. The patient is anesthetized, and the limb having been carefully protected with cotton, particularly about the malleoli, the patella and the inner condyle are enveloped in a firm plaster bandage reaching from the malleoli to the pubes. When the plaster begins to harden one assistant steadies the pelvis, another holds the inner condyle, while the operator draws the leg inward with moderate but persistent force against the fulcrum formed by the hand of the second assistant and holds it firmly in the partly corrected position until the bandage is hard. About three days later a wedge-shaped section of the bandage, about one inch in width, is removed from the part that covers the inner half of the knee, the other half of the bandage being simply divided. The leg is then forced inward until the two sections are again brought into contact. The position is retained by an additional plaster bandage about the weakened part. This procedure is repeated at intervals until the leg is completely straightened, a result that is often accomplished in a few weeks. No anesthetic is required for the secondary treatment. When the deformity has been corrected the patient is allowed to walk about, and for convenience the plaster bandage is divided into a thigh and leg part, which are attached by lateral joints incorporated in the substance of the plaster, so that movement is allowed. This apparatus must be worn for several months, and is of course to be supplemented by massage and exercises.

Another means of correction of deformity without open operation is that employed by Lorenz, what he calls "Intraarticuläre modelirende Redressement." In this operation the deformity is reduced under anesthesia at one sitting, by the gradual application of force by means of his osteoclast. The distortion is corrected partly by stretching the external ligaments and partly by straightening the bones. A plaster bandage is worn for six weeks when it is replaced by a jointed brace. As a rule, the patient is allowed to walk about in a few days after the operation.

ROYAL WHITMAN.

Koch, Robert.—Born at Klausthal, Germany, December 11, 1843. He studied medicine at the University of Goettingen, receiving his degree there in 1866. His early struggles to gain a practice were interrupted by the Franco-Prussian war during which he served as surgeon. At the close of the war he was appointed district physician at Wollstein. It was here that he began the work which was to bring him undying fame as the founder of the modern scientific method of bacteriological research. His first investigation was into the microparasitology of anthrax, and in 1876 he announced that he had succeeded in obtaining pure cultures of the anthrax bacillus and in tracing its life history. This immediately attracted the attention of the scientific world and in 1880 Koch was called to a position in the Imperial Health Department at Berlin. In 1882 he discovered the tubercle bacillus and in the following year the comma bacillus and the bacillus of infectious conjunctivitis, called usually the Koch-Weeks bacillus. In 1885 he was appointed professor of hygiene and bacteriology at the University of Berlin. On the occasion of the International Medical Congress, held in Berlin in 1890, Koch announced the discovery of tuberculin which he hoped would prove curative of tuberculosis. He was led to make this announcement prematurely, through the insistence of his lay superiors in the Imperial Board of Health, before he had experimented sufficiently to satisfy himself that the substance was really curative, and the result was a cruel disappointment. In 1891 he was appointed director of the Institute for Infectious Diseases just established in Berlin. In 1896 he went to South Africa at the request of the British Government to study the rinderpest and suggest means for its suppression or cure. In 1897 he introduced a new tuberculin (T.R.). In 1898 he went to Italy to study

FIG. 3613.—Robert Koch

malaria in the Roman Campagna. In 1900, at the Tuberculosis Congress in London, he startled the medical world with the assertion that bovine and human tuberculosis were distinct diseases and that tuberculosis in man was not caused by drinking the milk of tuberculous cows. This view was strongly opposed by the great majority of phthisiologists in all countries but Koch maintained to the end of his life his belief in the substantial correctness of this contention. In 1905 he was awarded the Nobel Prize for physiology. In 1906 he went to South Africa to study the sleeping sickness and recommended atoxyl in its treatment, but the remedy was abandoned when it was found frequently to cause blindness. In 1907 he studied leprosy in Hawaii, and in 1908 attended the Tuberculosis Congress at Washington, upon which occasion he again expressed his conviction that bovine tuberculosis was not communicable to man. He died of disease of the heart in Baden on May 27, 1910.

The following are the titles of some of the more important of the contributions of Koch to medical literature; these and many more are to be found in the "Gesammelte Werke von Robert Koch," in two volumes, published in Leipzig in 1912; "Die Aetiologie der Milzbrandkrankheit," Cohn's Beiträge, 1876; "Untersuchungen über die Aetiologie der Wundinfektionskrankheiten," Leipzig, 1878; "Zur Untersuchung von Pathogenen Organismen," Berlin, 1881; "Ueber Desinfektion," Berlin, 1881; "Ueber die Aetiologie der Tuberkulose," Berlin, 1882; "Die Aetiologie der Tuberkulose," Berlin, 1884; "Ueber die Cholerabakterien, *Deutsche med. Wochenschrift*, No. 45, 1884; "Ueber bakteriologische Forschung," Berlin, 1890; "Weitere Mitteilungen über ein Heilmittel gegen Tuberkulose," *Deutsche med. Wochenschrift*, No. 3, 1891; "Ueber neue Tuberkulin-präparate," *Deutsche med. Wochenschrift*, No. 14, 1897; "Reiseberichte über Rinderpest, Bubonenpest," etc., Berlin, 1898; "Seuchenbekämpfung im Kriege," *Klinisches Jahrbuch*, 1902.

The above is an imperfect chronicle of the activities of this wonderful man, almost every year of whose professional life was marked by some discovery either directly or indirectly of benefit to mankind. But

more than all else, he was the founder of the scientific method of bacteriological research; others might, and doubtless would in time, have discovered the pathogenic agents of tuberculosis, of anthrax, and of cholera, for he had blazed the path and made the way easy, but it is not certain that others would—certainly none did, lay so securely the foundations of modern bacteriology. Immeasurably great is the benefit conferred upon mankind by Robert Koch, and his name, with that of Pasteur, deserves to be held in grateful remembrance by the inhabitants of every country on the face of the globe, for thousands in every land owe their health and their lives to the science so firmly established by him. T. L. S.

Koelliker, Rudolf Albert.—Born at Zürich, Switzerland, July 6, 1817. He studied medicine at the universities of Bonn, Berlin, and his native city, and received the degree of Doctor of Philosophy from the latter institution in 1841. During the following year he received his degree of M. D. from the University of Heidelberg. In 1842 he was an Assistant in Anatomy at Zürich, under Professor Henle. In 1843 he was made a Privatdozent, and in 1845 he was

Fig. 3614.—Rudolf Albert Koelliker.

given the Chair of Physiology and Comparative Anatomy in the same university. From 1847 to 1866 he held the same professorship in the University of Würzburg; but from the latter date to 1892, when he celebrated the fiftieth anniversary of the year in which he received his medical degree, he taught anatomy, microscopy, and embryology. In 1896 he was made a Knight of the "Order of Merit." He died in 1905.

Koelliker occupies a very distinguished place in the history of medicine as a biologist. Of his numerous published writings the following deserve to receive special mention: "Handbuch der Gewebelehre für Aerzte und Studierende," two volumes, Leipzig, 1852 (the latest edition in 1896); "Entwickelungsgeschichte des Menschen und der höheren Thiere," Leipzig, 1861 (also later editions); and "Die Entwickelung des Auges und Geruchsorganes menschlicher Embryonen," Leipzig, 1883. A. H. B.

Kola Nut.—See *Cola*.

Koprosterin, Koprosterole.—By this term is designated a substance occurring in human feces related to cholesterole by being a reduction product of the latter. Its formula is probably $C_{27}H_{48}O$ and it may be regarded as a dihydrocholesterole. It was first prepared by Flint and by him called stercorin. Koprosterin is soluble in cold absolute alcohol, ether, chloroform, and benzene and crystallizes in fine needles having a melting-point of 95–96° C. It is dextrorotatory, $(\alpha)^D = +24°$ and yields nearly all the reactions given by cholesterole. In the feces of the horse may be found a similar substance, hippokoprosterin, $C_{27}H_{44}O$.
F. P. U.

Korsakoff's Psychosis.—See *Alcoholic and Drug Addiction*.

Kramer, Wilhelm.—Born at Halberstadt, Germany, Dec. 17, 1801. He studied medicine in Goettingen and Berlin, and received the degree of Doctor of Medicine from the latter university in 1823. About two years after graduation he began to devote his attention seriously to etology, and he continued to make this his special field of labor during the following fifty years. During the latter half of his life the title of "Geheimer Sanitätsrat" was conferred upon him in recognition of his valuable contributions to this department of medical knowledge. He died at Berlin December 7, 1875.

Kramer was one of the first physicians in Germany —probably in Europe—to devote himself exclusively to otology. His first, and at the same time his most important, contribution to medical literature bears the title: "Erfahrungen über die Kenntniss und Heilung der langwierigen Schwerhörigkeit," Berlin, 1833. In 1849 the book was thoroughly revised, and was then published under the title: "Die Erkenntniss und Heilung der Ohrenkrankheiten." Kramer is credited by Pagel with the distinction of having been the first to employ the catheter and auscultation in ascertaining the condition of the middle ear; to pass bougies through the catheter; and to treat affections of the middle ear which are not associated with a perforated drum membrane, by means of the catheter and the elastic air bag. Of Kramer's other published writings the following deserve to be mentioned: "Die Heilbarkeit der Taubheit, zur Beherzigung für Ohrenkranke und deren Aerzte," Berlin, 1845; and "Ueber den Werth der ohrenärztlichen Erfahrungen, mit besonderer Rücksicht auf Schmalz's Erfahrungen und Beiträge," Berlin, 1842. A. H. B.

Krameria.—Rhatany. The dried roots of several species of Krameria, especially of *K. triandra* R. et P., *K. ixina* L., and *K. argentea* St. Hil. (fam. *Krameriaceæ*).

The Kramerias are low or semi-prostrate shrubs of tropical or warm temperate parts of America. They have very long, thick roots, noted for the thickness of their bark. Since the active constituent exists mostly in the cortex, the thicker barked varieties are the better. The first-named grows in the higher Andes and yields Peruvian Krameria, the poorest variety. The second comes from the Santa Marta region of Colombia, and is about intermediate in quality between the first and the third, which latter comes from Northern Brazil. This is usually sold as Savanilla, the genuine Savanilla now reaching the market only occasionally. *K. lanceolata* Torr., of the Southwestern United States and Northern Mexico, yields a good Krameria, but it is scarcely a commercial article.

Description.—*Peruvian Krameria.*—Root branches usually occurring with several or many attached to a short, hard, and woody tap root, which is 1.5–4 centimeter ($\frac{1}{2}$–$1\frac{1}{2}$ inch) thick, roughly fissured and supports a knotty, several- to many-headed crown; of indefinite length, rarely exceeding 50 centimeters (20 inches) and usually less than 1 centimeter ($\frac{3}{8}$ in.) thick, cylindrical, flexuous or wavy, very flexible; externally light red-brown, more or less marked with dark, scaly patches, especially upward, otherwise smoothish, devoid of transverse fissures; fracture tough and splintery, the pinkish-brown bark occupying less

than one-third of the radius, the wood yellowish or pinkish-white, finely radiate; inodorous and of a very astringent taste.

Brazilian Krameria.—Branches usually occurring detached from the tap root and crown, less flexuous than those last described, externally of a deep purple-brown or chocolate-brown and with numerous transverse cracks or fissures; fracture less tough than that of the last, the bark and wood both darker, the former occupying two-fifths, or even more, of the radius, the taste more astringent than that of the last.

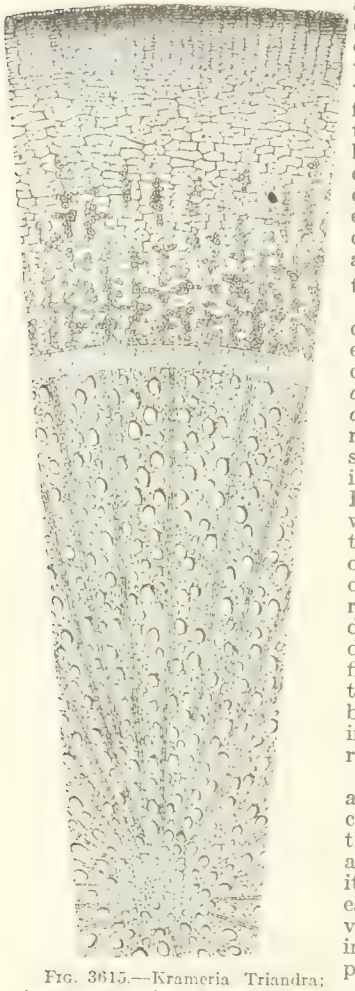

Fig. 3615.—Krameria Triandra; transverse section of root. (Baillon.)

The most important constituent is from eight to twenty per cent. of *krameria-tannic acid* or *rhataniatannic acid*, a brilliant deep red amorphous mass, soluble in alcohol and, if pure, in water also. It is usually only partly water-soluble, owing to the change of a portion of it to phlobaphene by dehydration. Krameria-tannic acid gives a dull green color with diluted acids, and is flesh-colored with gelatin. It is decomposed by dilute mineral acids into sugar and rhatania red.

Published statements as to the relative percentages of tannin in the different varieties are not reliable, since it is the very commonest occurrence for the varieties to be confused in commerce and in experiments.

Rhatany is a reliable and useful astringent, owing to its tannin, and is applicable to all conditions in which gallic or tannic acid is useful. The crude drug may be given in powder, in doses of gr. xv.–xxx. (1.0–2.0), though a liquid preparation is preferable. The pharmacopœia provides an extract, the dose of which is two to four grains, a fluid extract, dose fifteen to thirty minims, and a twenty per cent. tincture, the dose of which is from one to two fluidrams.

Henry H. Rusby.

Kronecker, Hugo.—Born in Liegnitz, Silesia, in 1839. His medical education was obtained in Heidelberg and Berlin where he was graduated in 1863. At the time of his graduation he evinced a fondness for physiology, his dissertation dealing with muscular fatigue. He acquired his practical knowledge of medicine as assistant physician, under Traube, and served in the campaigns of 1866 and 1870–71 as an army surgeon, for which services he received the decoration of the Iron Cross. In 1868 he was called to Leipsic and became assistant to Carl Ludwig. In 1872 he was made privat-docent, and in 1875 was elected professor extraordinary in the University. In 1877 he was called to Berlin, where he remained until 1885 when he became professor in Berne, and in the line of succession of Haller. He termed his institution in Berne the "Hallerianum." His death occurred suddenly on March 12, 1914, at Nauheim, where he had gone to attend a meeting of the German Physiological Society.

Kronecker was one of the best known and most distinguished of the physiologists of the twentieth century. He wrote comparatively little, but his work has made a distinct impression and influence on the knowledge of physiology. He is best known by his dissertation "On the Fatigue and Recovery of Cross-striped Tissue," published in 1872. For some years together with Senator, he edited the *Centralblatt für die medizinischen Wissenschaften.* His studies on muscle form the basis of our knowledge of the laws governing muscular fatigue. His researches on excised living organs, especially the heart, uterus, and vagina; his study of reflex action, respiratory movements, swallowing of fluid, sources of animal heat, the action of cardiac poisons show his many-sidedness in the realm of physiology. He discovered, independently of Marey, that during the first part of a cardiac contraction the heart is irresponsive to stimuli. Kronecker's center or point in the heart is the same given to the inhibitory cardiac center. During the latter part of his life he made important studies on the effects of rarefied air on the circulation, which have borne practical results in the process of tunnelling through mountain masses.

E. L. J.

Kuehne, Willy.—A distinguished German physiologist of the nineteenth century. Born at Hamburg, March 28, 1837, he received his professional training at the universities of Goettingen, Jena, Berlin, Paris, and Vienna, mainly under the guidance of such eminent teachers as Woehler, R. Wagner, Weber, Henle, Lehmann, Virchow, Claude Bernard, Ludwig, Bruecke, and DuBois-Reymond. In 1856 he obtained the degree of Doctor of Philosophy, and in 1862 that of Honorary Doctor of Medicine was given to him. In 1868 he received the appointment of Professor-in-Ordinary of Physiology at Amsterdam, and three years later he was given the same position at the University of Heidelberg, with the added duty of acting as Director of the Physiological Institute. He died in 1900.

The following are the titles of some of his more important published writings: "Myologische Untersuchungen," Leipzig, 1860; "Untersuchungen über das Protoplasma und die Contractilität," Leipzig, 1864; "Physiologie des Gesichtssinnes," in Hermann's Handb. der Physiol., 1879; and numerous shorter essays in Untersuchungen aus dem physiologischen Institute zu Heidelberg, 1877–1882.

A. H. B.

Kuhn, Adam.—Born in Germantown, Pennsylvania, November 28, 1741. From his father, who was a physician by profession and a liberally educated man, he received a careful elementary training in the classics and also to some extent in medicine. In 1761 he went to Europe and resorted to Sweden for instruction in botany and materia medica at the hands of Linnaeus, the famous naturalist. He subsequently went to Edinburgh, and received the degree of Doctor of Medicine from the University of that city in 1767. On his return from Europe he settled in Philadelphia and practised medicine. In January, 1768, he was appointed the Professor of Materia Medica and Botany in the Medical College of Philadelphia, and in November, 1789, he became the Professor of the Theory and Practice of Medicine in

the University of Pennsylvania. He was also one of the physicians of the Pennsylvania Hospital, from May, 1775, to January, 1798. He died July 5, 1817.

A. H. B.

Kumyss is the mixture of substances obtained from mare's milk when it has been subjected to the action of alcoholic and lactic acid fermentation. See *Kephir*.

F. P. U.

Kussmaul, Adolf.—Born at Graben, near Karlsruhe, Germany, February 22, 1822. He studied medicine at Heidelberg, Vienna, and Prague. After practising for a few years he was obliged, owing to illness, to abandon all work for some time. In 1857 he was chosen Professor Extraordinary in the University of Heidelberg, and in 1859 he accepted a call to Erlangen, to occupy the regular chair of internal diseases. Later he accepted a similar position in the University of Freiburg (in Breisgau); and finally, in 1876, he became a member of the Faculty of Strassburg. He died in 1902.

Of his numerous contributions to medical literature the following deserve to receive special mention: "Untersuchungen über das Seelenleben des neugeborenen Menschen," Leipzig, 1859 (3d edition, Tübingen, 1896); "Ueber die Behandlung der Magenerweiterung durch eine neue Methode," Freiburg in Breisgau, 1869 (the employment of the stomach pump in the treatment of affections of the stomach is here advocated for the first time); and "Die Störungen der Sprache," in von Ziemssen's Handb. der Pathologie, 1877 (2d edition, 1881).

A. H. B.

Kyphosis.—The term "kyphosis" is derived from the Greek κυφός meaning humpbacked, bent forward, and signifies of course, only a symptom, but one which is present in a number of conditions both of disease and of injury. It always refers to the spine, and, inasmuch as tuberculosis of the spine is the disease which almost invariably presents this symptom as its most conspicuous clinical feature, the term kyphosis is perhaps most generally supposed to refer to this disease. It always signifies an anteroposterior curvature.

We will consider the spinal column a moment from an anatomical point of view before taking up the pathological changes causing kyphosis. The column above the sacrum is composed of vertebræ which diminish in size as one approaches the atlas; these are separated by fibrocartilaginous discs which equal one-fifth of the whole bony column in height and are more or less elastic and compressible. The vertebræ are kept in place by ligaments outside the vertebral canal as well as within the canal itself. These have some elasticity and allow motion of the vertebræ on their articular facets. In addition to the support afforded by the ligaments the column is maintained erect by the powerful spinal muscles, and in the lumbar region by a fibrous aponeurosis as well. When these anatomical features are present in a normal condition, under normal relations one to the other, then the column in the erect position presents certain normal physiologico-anatomical curves dependent chiefly upon where the center of gravity passes through the column. In a normal individual this is as follows: A perpendicular line should pass through the odontoid process, and then through the body of the second dorsal vertebra; thence it should intersect the column at the tenth and eleventh dorsal vertebræ and then pass on down through the sacrum. It is important to remember this because a lack of familiarity with the normal curves of the spine and the variations which may take place in it within normal limits is the source of much confusion and oftentimes of positive wrong, particularly in medicolegal work. Certain vertebræ at the junction of the cervical and dorsal portions of the spine are invariably more prominent than elsewhere. Again, in the lower dorsal and upper lumbar regions there are also two or three spinous processes which are more conspicuous than their fellows, particularly in flexion of the column. Posture, occupation, etc., readily aggravate such conditions, when once they are present, as does also the lack of subcutaneous fat. There are also congenital defects in the spine which give rise to a bending forward of the column, or at least an apparent bending of it. Certain of the anomalies of development which may cause a modification of the lumbar curve, transforming it sometimes even from a lordosis to a kyphosis, are concerned with the lumbosacral and sacroiliac joints. Traumata inflicted upon these abnormal articulations may so disturb them that the spasm of muscles so induced will flex the spine, creating the impression that a structural anteroposterior deformity is present. The defects are most commonly in the cervical region and in the lower dorsal or the lumbar region. In the latter region occur the spinæ bifidæ; in the former, the meningo-encephaloceles.

1. To distinguish normal curves from pathological ones is not commonly difficult. The meningo-encephaloceles are the result of a failure of the posterior neural arches to unite, and a protrusion of the coverings of the cord ensues, either complete or partial. Many of these cases do not live longer than through the period of infancy, but occasionally, when the bony arch has not failed completely to unite, the patients survive and have a very short neck with high standing shoulders and considerable deformity. The spinæ bifidæ, which commonly occur in the lower dorsal or the lumbar region, are readily recognized by the soft and fluctuant character of the swelling, which is in the median line, and is accompanied usually by more or less paralysis of the lower extremities, both sensory and motor. The kyphosis is not due to alterations in the bone.

2. Trauma may cause kyphosis, and frequently does. Under this head come the fractures of the spine which are commonly accompanied by considerable deformity and by more or less paralysis below the deformity, both motor and sensory, involving the sphincters also. The bend is sharp, and involves as a rule only two or three vertebræ at the most. Dislocations of the spine cause kyphosis frequently. They are more common in the cervical region. They are not apt to cause as complete paralysis as do the fractures, and they are amenable to treatment. Another sort are the so-called "torsions," or ruptures of spinal ligaments in which there is more or less motor and sensory disturbance below the seat of injury; a kyphosis is present on flexing the trunk, with an aggravation of the above-mentioned symptoms, which disappear, as does also the kyphosis, when the trunk is hyperextended. This kyphosis manifests itself in the form of a sharp bend involving two or three vertebræ.

3. In young children with acute rickets a kyphosis is very common. This curve is a long sweeping one, involving pretty much the entire dorsal portion of the column, but is not accompanied by muscular spasm; the curve disappears entirely on hyperextension of the trunk, and the child commonly presents the other evidences of acute rickets, viz., pain on handling, enlarged epiphyses, rosary, prominent abdomen, etc.

4. Osteoarthritis frequently attacks the spine and causes anteroposterior deformity. This occurs most often in adults, usually men. The forward and backward motions of the spine are restricted; the kyphosis involves several of the vertebræ and is produced by the lipping of the cartilages about the vertebral bodies, and this lipping is so situated on the anterior portions of

the vertebral bodies that the complete flexion and extension of the spine are limited. These deposits are analogous to Heberden's nodes in the terminal phalanges of the fingers.

5. Rheumatoid arthritis seldom attacks the spine, but when it does it causes an atrophy of the intervertebral discs, as a result of which the spine manifests a long sweeping curve, which cannot usually be corrected without pain and spasm. Other joints invariably manifest the characteristic lesions. It is a disease of young adult life, and, so far as it involves the spine, is apparently more common in men.

6. Osteitis deformans, or Paget's disease of bone, is a disease of late adult life, occurring in men usually and resulting in an anteroposterior flexion of the whole spinal column together with considerable thickening and bowing of the long bones. The column becomes usually completely ankylosed. The kyphosis shows itself in these cases in the form of a long sweeping curve.

7. Osteomalacia, most often seen in women in adult life and during the parturient state, causes occasionally a kyphosis. As a result of the slow softening which takes place in the bony structures of the spinal column in this disease the latter gradually assumes a moderately pronounced degree of curvature—one quite different from the sharp bend that follows the inflammatory type of bone disease. At the same time evidences of the same morbid process will be observed in other bones of the body.

8. By far the greater number of anteroposterior curves in the spine are caused by tuberculosis (Pott's disease). In these cases the spine becomes sharply bent, during the active stage of the disease, at some one point, owing to the fact that at this time only one or two vertebræ are involved. The disease is most common in childhood, and is about equally distributed as to sex. It may involve any part of the spinal column, but is most common in the dorsal, somewhat less so in the lumbar, and least common in the cervical region. It cannot be obliterated by hyperextension, and is accompanied by muscular spasm in the spinal muscles at the seat of the disease. It is by no means uncommon in adults, either as an acute or as a chronic process, as late as middle life. It is usually slow in development.

9. Acute osteomyelitis attacks the spine not infrequently. It is acute in onset and may follow some septic process such as tonsillitis or other infectious disease. It causes some kyphosis, though not the acute bending of the spine that is observed in Pott's disease. There is much pain, chiefly local in character, and considerable fever is present. In most cases suppuration takes place and sequestra are formed. The whole course is much shorter than in Pott's disease, and the deformity is much less and is due more to muscle spasm than to destruction of vertebral substance.

10. Malignant disease, both carcinoma and sarcoma, is said to occur primarily in bone, but is much more commonly secondary to malignancy elsewhere—in the case of the carcinomata usually the breast, the prostate, or the intestine. The bend in the spine is generally of small size, and is due to the destruction of the bone trabeculæ by the cancerous infiltration. The most striking feature is the great pain of which these patients complain. The disease develops slowly and is characterized by marked cachexia, and the peripheral sensory disturbances predominate over the peripheral motor disturbances, the reverse of the condition seen in Pott's disease. Malignant disease occurs in adults and rather more frequently in women than in men.

Sarcomatous kyphoses may be either primary or secondary, the latter usually following sarcoma in the kidney. They occur in childhood most commonly, and are more rapid in development than those due to carcinoma.

11. Occasionally the muscular dystrophies, by causing a sharply limited muscular atrophy, give rise to an apparent kyphosis where the atrophy of the spinal muscles stops and the normal muscle commences. This ought to cause no difficulty in diagnosis, as the atrophy which could possibly cause any such confusion is usually confined to the scapular group of muscles and the spinal muscles in the immediate vicinity, and the atrophy and loss of power in the scapular groups would show clearly the diagnosis, aside from the absence of other spinal symptoms.

12. In this same category we have infantile paralysis, involving the trunk muscles and causing a long sweeping curve in the spine with prominence of several spinous processes. The patients are unable to sit erect, and, besides the history of infantile paralysis and the usual presence of paralysis elsewhere—*e.g.* in the extremities, the muscles being flaccid—there is abnormal mobility in the spinal column in all directions, with entire absence of muscle spasm.

13. Certain functional conditions in the region of the spine may also cause a kyphosis. They are associated, as a rule, with the neurasthenic state, but sometimes they are simply the result of the loss of muscular tone in rapidly growing children, particularly girls, or in patients who are convalescing from pregnancy or from some acute disease. Finally, they are also observed in the blind as a result of an habitually faulty posture. The curve observed in such cases is of the long, sweeping character, and may easily be corrected by suitable manipulations. It is not accompanied by spasm, but in the neurasthenic it is frequently associated with hyperesthesia along the spinous processes.

Under this functional head should be included the hysterical curvatures.

14. Syphilis. The tertiary manifestations of this disease are occasionally seen to cause an anteroposterior curvature of the spine. The character of the bend in the spine and the symptoms which occur differ but little, if at all, from those seen in Pott's disease, and the history must be chiefly relied upon for establishing the diagnosis. These cases will respond to antisyphilitic treatment, and they are less apt to be accompanied by a cold abscess.

15. Typhoidal, Gonococcal, and Postscarlatinal Kyphosis. In the kyphoses which are due to these diseases the absence of any protrusion along the course of the spine or of any suggestive symptoms, prior to the onset of the acute disease, must first of all be established. The deformity in these cases develops much more rapidly than it does in other forms of the disease; furthermore, the first evidences of the change are usually observed during the acute stage or at least early in that of convalescence. The entire course of the disease is of much shorter duration than it is in any of the other forms of kyphosis. The results obtainable from treatment are also apt to be better.

16. Mollities Ossium, Hydatids, Actinomycosis, and Aneurysms. A very rare cause for kyphosis is the process of bone softening known as mollities ossium. This occurs more commonly in children than in adults, and the spinal column is just as liable to be affected as are any other parts of the bony framework. The fact that the softening rarely if ever affects any one part of this framework alone should aid one materially in making the differential diagnosis.

The presence of hydatids, forming cysts in the vertebral bodies, is extremely rare, but has occurred. A correct diagnosis can of course be made only after the discovery of the hooklets in the contents of the opened cyst.

Of about equal rarity is the occurrence of actinomycosis as a cause for kyphosis; this also could be demonstrated as the cause only by finding the fungus in any pus coming from the spine of a patient thus affected.

The pressure made by an adjoining aneurysm may cause erosion of one of the vertebral bodies and thus lead to a kyphosis having an anteroposterior curve. The pain, while this process is going on, is very severe. Such cases occur almost always in middle adult life,

and careful examination at repeated and short intervals may clear the diagnosis.

The foregoing, in brief, are the principal causes for kyphosis.

The nature of the process that gives rise to a bony kyphosis must be determined through a consideration of (*a*) the history, (*b*) the duration, (*c*) the onset, (*d*) the presence or absence of muscular spasm, or of bony ankylosis, (*e*) the presence, either immediate or remote of diseases elsewhere in the body which, if present in the spine, would cause a kyphosis, and lastly (*f*) the presence or absence of paralytic conditions in the spinal muscles. CHARLES F. PAINTER.

Kyrine.—By hydrolytic cleavage of gelatin and certain other proteins a basic body may be obtained which is regarded by some investigators as constituting a portion of the original protein molecule. This substance has been called kyrine. The various kyrines show a different composition, as measured by the products they yield, according to the nature of the protein from which they were derived. F. P. U.

Labiatæ.—(*The Mint Family.*) A very large family of more than one hundred and fifty genera and about three thousand species, growing in almost all parts of the world. The constituents and properties of these plants are so uniform, and so important, that their recognition is highly desirable. They have square stems, opposite, and most always aromatic, but not punctate leaves, the corolla usually, and the calyx frequently, bilabiate, the stamens, two, or four and didynamous, the ovary two-carpelled and maturing in the form of four one-seeded nutlets. The last character distinguishes them from the closely related Scrophulariaceæ, which are frequently poisonous, while the Labiatæ never are. These plants are often exceedingly showy. Their only other value resides in their almost invariably aromatic properties, due to the presence in them of volatile oils. The mints, lavender, rosemary, pennyroyals, thyme, and many others of the family are treated in this work in their proper order. A host of others might be enumerated. Some of those more commonly used are the sweet marjoram (*Origanum majorana* L.), summer savory (*Satureja hortensis* L.), dittany (*Cunila mariana* L.), hyssop (*Hyssopus officinialis*, L.), *Ajuga*, *Cedronella*, various species of *Monarda*, *Koellia* (*Pycnanthemum*), *Calamintha*, and *Orthosiphon*. Others contain a bitter substance also, and are used as aromatic bitters. Representatives of this class, treated in this work, are horehound and sage. Those of minor importance, of the same class, deserving of mention, are wild origanum (*O. vulgare* L.), glechoma or ground ivy (*Glechoma hederacea* L.), germander (*Teucrium chamædrys* L. and various other species of *Teucrium*), motherwort (*Leonurus cardiaca* L. and other species of *Leonurus*), many species of *Mesosphærum* (*Hyptis*) and *Ocimum*, and several of *Lamium*, heal-all or *Prunella* (*Brunella*), *Lycopus*, or bitter bugle and *Scutellaria* or skull-cap. Occasionally these plants, as in the case of salvia, combine a considerable amount of tannin with their volatile oil and amaroid, and have distinctly astringent properties.

HENRY H. RUSBY.

Labor.—In the following article this subject will be considered under the heads of A. Physiology, including mechanism; B. Pathology; and C. The management of normal and abnormal labor.

Definition.—The term labor is applied to that process which results in the expulsion of the mature, or nearly mature, product of conception from the interior of the uterus.

A. PHYSIOLOGY OF THE COURSE OF LABOR.—*Causes.*—Both speculative and scientific research have been called upon to explain the reason for the onset of normal labor at the end of a period which has been found to include about 280 days after the appearance of the last menstrual period. No satisfactory explanation has, however, been discovered and among the many theories which have been advanced, attention may be called to the following summary (based on J. W. Williams' text-book), as being the most important and reliable.

1. *Increased Sensitiveness of the Uterus to Stimuli at the End of Pregnancy.*—It is well known that the uterus reacts to stimulation both from external and internal sources during the latter months of pregnancy much more readily than at other times, and the regular intermittent contractions of the organ which may be noted during pregnancy itself come on more frequently during this period and also with greater intensity. For this reason irritants or other stimuli transmitted through the nervous musculature or digestive systems may serve to start the process. We know for example that an attack of acute indigestion, nervous shock, muscular exertion, intestinal colic, and a number of other conditions may promptly induce labor by an apparently reflex stimulation of the nerve supply or musculature of the uterus.

2. *Increasing Distention of the Uterus by its Contents.*—Any hollow viscera which is distended beyond a certain point ordinarily begins to contract and empty itself. We see this exemplified in the stomach and also the rectum, and the presumption seems to be supported by the fact that premature births frequently occur in cases of hydramnios or twin pregnancies. On the other hand, we often find that distention beyond a certain point seems to produce a paralysis of the organ and is accordingly met with in cases of prolonged pregnancy, especially with very large children.

3. *The Dilatation of the Cervix by the Presenting Part.*—This is a theory already proposed by Galen, who believed that the pressure of the presenting part on the cervix was sufficient to bring about its dilatation. We find, however, in multiparæ, a degree of cervical dilatation existing for weeks before labor which apparently controverts this theory.

4. *Increasing Distention of the Lower Uterine Segment with Pressure upon the Neighboring Nervous Structures.*—This theory does not seem to afford a satisfactory explanation, as we find labor coming on in many cases where the presenting part is not at all in contact with the lower uterine segment and no possible pressure effect can take place.

5. *Changes in the Decidua.*—The claim has been made that the decidua in the later weeks of pregnancy undergoes fatty degeneration which results in the partial separation of the ovum and its practical conversion into a foreign body. The latter gives rise to uterine contractions as in the case of any other hollow viscus, but investigation has shown that fatty degeneration, if it does occur, is not a normal state. Whether the ovum becomes separated by the thinning out of the spongy layer of the decidua in the last few weeks of pregnancy is doubtful.

6. *Excess of Carbon Dioxide or Lack of Oxygen in the Placental Blood Acting on the Nerve Centers.*—Brown-Séquard first demonstrated in 1853 that an excess of carbon dioxide in the blood led to energetic uterine contractions. Although this may be true it has not been shown why sudden increase in the carbon dioxide in the blood occurs at a stated time, although it has been claimed that this gas in the placental blood is markedly increased as the result of progressive thrombosis of the decidual vessels. Later investigators claim that no contractions arise as the result of an excess of carbon dioxide in the blood.

7. *Circulation of Fetal Metabolic Products Acting upon Similar Centers.*—It is claimed that the mature fetus needing materials for its sustenance other than

those furnished by the placenta, certain substances are excreted which gain access to the maternal circulation and thus stimulate the uterus. A great many observations have been made along these lines which seem to indicate that the ultimate cause of labor may be a substance circulating in the maternal blood, of the nature and origin of which we are, however, ignorant. It has been shown that a uterus which is cut off from all connection with the central nervous system, will go into labor at the usual time and proceed to empty itself normally. The process does not therefore seem to be dependent upon the stimulation of centers situated in the central nervous system, but is due to the stimulation of intrauterine ganglia by substances either brought to the uterus by the circulating blood or originating in the fetus itself.

8. *Menstrual Periodicity.*—The increased tendency toward uterine contractions at what would have been menstrual periods is believed to reach its acme at about the time of the tenth menstrual period and thus gives rise to labor. Observations of this character point toward the possibility of an ovarian hormone being the exciting cause.

9. *Anaphylactic Action of the Fetal Blood.*—It is claimed that in a certain proportion of cases, labor will follow intravenous injection of a small quantity of fetal serum. In normal pregnancy fetal substances are constantly gaining access to the maternal circulation which give rise to definite antibodies. As full term approaches and excessive quantities of the fetal antigens enter the maternal blood, in the reaction which ensues between the latter and the existing antibodies, substances are set free which give rise to labor. There is, however, very little confirmatory evidence to support this view.

10. *Heredity and Habit.*—This theory is based on the fact that Nature after the lapse of many ages has found that the tenth lunar month is the most suitable time for the delivery of the fetus. At this period the relations between the average child and the maternal pelvis are such that it is born with the least difficulty, whereas, if the process is prolonged beyond this date, the death of the fetus is apt to result from the prolonged and difficult labor, and if born at an earlier period it is insufficiently developed to maintain its existence and perishes.

11. *Senility of the Placenta.*—The frequent occurrence of infarct formation in the placenta at term has been accepted as evidence of its senility and is analogous to atrophy of the chorion at an earlier period. This interferes with the nutrition of the fetus and possibly results in the formation of metabolic products which stimulate the uterine centers to contraction.

None of these theories can be applied universally and in the majority of cases the onset of labor is probably due to a combination of several of the above-mentioned causes. On the other hand it is possible that some law may be discovered which will explain the physiology of the various sexual functions in women, including menstruation as well as the onset of labor. Williams has shown that a marked change in metabolism occurs immediately before and at the time of labor, which he believes probably stands in some causal relation to the same. This includes a diminution in the nitrogen output through the urine, while at the same time a marked diuresis occurs, thus a complete reversal of what ordinarily takes place during the last months of pregnancy. Although long believed that the central nervous system included in the medulla a center for uterine contractions, which could be stimulated by anemia and the presence of various toxic substances, recent investigations render it probable that the only uterine center is situated in the lumbar portion of the cord and that this is not absolutely essential to the process of normal labor. It may be concluded therefore that the intrinsic nerves of the uterus are the most important factors in the production of the contractions of this organ and that the central nervous system exerts merely a regulative function, making possible the perception of pain and the control of the reproductive organs, whereas the sympathetic system regulates the vascular conditions.

Labor Pains.—The onset of labor is marked by the change in the character of the intermittent contractions of the uterus which have existed throughout the pregnancy and which instead of being comparatively painless, are felt to a greater or less degree by the patient. The contractions of the uterus are independent of voluntary effort, and can be neither directly increased nor diminished by this means. Emotional stress, however, may either increase or stop them entirely. Although labor theoretically begins with the process which finally results in the expulsion of the fetus, we are accustomed to compute the length of the pains from the time when the pains become perceptible. Analysis of each pain shows that it begins slowly, and gradually reaches a point which is synchronous with the transitory tonic contractions of the uterus. Up to the latter point the pains are effective in dilating the lower uterine segment and the cervix but at the height of the period they are of no value from a mechanical standpoint and it is essential that complete relaxation results before the advent of another pain. The so-called labor pains vary in different individuals, but they usually begin in the back and in time extend around to the front of the abdomen. The intensity of the pain usually varies with the progress of the labor. At the beginning they may be very slight and amount to a sense of mere discomfort, whereas toward the end of the stage of dilatation they may be severe and excruciating in character. The interval also varies from a period at the beginning of one-half an hour or more to a frequency of every two or three minutes. The average duration also varies from a half minute to a minute. The duration of the pain is not, however, synchronous with the uterine contraction and we may find the uterus beginning to contract before the pain becomes evident. During the stage of dilatation the character of the pains depends somewhat on the resistance of the cervix and we find that where this does not dilate readily, as in a dry labor or in the presence of scar tissue, the severity of the pains may be very much increased.

The force of the labor pains has been calculated by a number of investigators and experiments have shown that a force of as much as fifty pounds pressure may be exerted during the height of the expulsive effort.

Clinical Course of Normal Labor; Stages, Duration.—It is convenient to divide the course of a normal labor into three stages. The first includes the time from the beginning of the real pains to the complete dilatation of the cervix and may be called the stage of dilatation. The second is the period of expulsion and dates from the completion of the dilatation of the cervix to the birth of the child. The third or placental stage lasts from the time of the birth of the child to the expulsion of the placenta. During the first stage the involuntary contractions of the uterus are the chief factor and bring about a dilatation of the softened cervix by the intermittent protrusion of the bag of membranes through the same. During this time the latter become separated from the lower uterine segment and a bloody discharge may be noted. As a rule the patient experiences no sensations between these pains and is preferably up and about during this period. This stage of the labor may vary in extent from a few to many hours and its end is often marked by the rupture of the amniotic sac at the time of full dilatation when drainage of the contained liquor occurs. In other cases the membranes may rupture before complete dilatation and in such cases the labor is apt to be more prolonged because dilatation of the cervix is gained by the impact of the hard

and more unyielding head or breech rather than by the soft fluid wedge of the amniotic sac. Where rupture occurs early in the process the term "dry labor" is applied. This will be further discussed in the section on the pathology of labor. After full dilatation is complete and the membranes are ruptured, the pains increase in severity and the involuntary uterine contractions are supplemented by voluntary expulsive efforts made by the patient with her abdominal muscles. The patient during this stage is very apt to lie down or assume a crouching position. The pains normally are increased in length and frequency and during their presence the patient assists by contracting her diaphragm and using the abdominal muscles as already referred to. As the head in a normal labor descends through the pelvis during this stage, pressure on the bladder and rectum results and the patient has a frequent desire to empty one or both of these organs. Observation of the vulvar outlet will also show a bulging of the latter with each pain and after a time the scalp may be detected in the slit thus formed. As the labor progresses the vulvar outlet and the perineum become more distended until the fourchette in an unlacerated perineum becomes as thin as a sheet of paper. It will be observed that the head advances with each pain and recedes during the interval until it is finally born. The vulvar outlet then contracts around the neck of the infant and congestion in the face of the latter will be noted. With the next pain, however, the anterior shoulder slips out from under the symphysis and then the posterior shoulder emerges over the perineum after which the remainder of the body is born, to be followed by a gush of amniotic fluid and frequently of some blood. The further details of the delivery will be found described in the paragraph on the mechanism of labor. The duration of this stage is ordinarily from two to four hours depending on the parity of the patient.

After the birth of the child there is usually a cessation of the pains, the uterus contracts and the patient rests for a period varying from a few minutes to an hour. At the expiration of this time the uterus begins to contract again and the placenta is expelled. The first step is the separation of this organ from the uterine wall, following which the contractions of the uterus force it down and into the lower uterine segment or the upper part of the vagina. It may be spontaneously expelled from the latter position by the contractions of the abdominal muscles or it may be necessary for the attendant to express the same by manipulations. A greater or lesser degree of hemorrhage usually results during the third stage which normally amounts to about 400 c.c. or less. The chill which is often noted at this time is merely the result of a vasomotor readjustment and has no particular significance.

The average duration of labor has already been referred to and varies with the parity of the patient. As a general rule from eighteen to twenty-four hours are required by primiparæ for complete delivery; in multiparæ this period may be from six to ten hours shorter without becoming abnormal. The slower course of labor in primiparæ is merely due to the increased resistance of the soft parts, but even this in vigorous young women may not be sufficient to extend the length of their labor beyond a few hours. In elderly primiparæ, however, the process may be considerably prolonged and has been estimated to average seven hours longer in them than in younger women. The satisfactory progress of a normal labor may be gauged by the regularity of the pains, resulting in a gradual dilatation of the cervix with unruptured membranes. The liquor amnii contained in that portion of the sac in front of the head is called the fore-waters and, as the head engages firmly in the pelvic inlet, this fluid cannot return and the membranes remain tense between the pains, with a resultant tendency to rupture. This rupture should correspond in a perfectly normal case to the time of full dilatation or dilatability of the cervix.

On the other hand, if the head does not engage in the pelvis the entire effect of the pains is exerted on the bag of membranes, and the latter is very apt to be ruptured prematurely before the cervix is sufficiently dilated. The latter process must then be completed by the head itself, which is apt to increase the pains and the length of the labor to such an extent that real danger for both mother and child may result. On the other hand, unruptured membranes may interfere with the progress of the labor, especially if they are tough, even after the cervix is completely dilated. If under these conditions the presenting part is at or below the brim, there is no objection to artificial rupture of the membranes with the finger, or a nail pick, or a knitting-needle. In some cases the child may even be born without the membranes having been ruptured and unless immediately relieved the fetus may become asphyxiated.

Mechanism of Labor.—In a normal labor the fetal head should present with the occiput pointing toward the mother's pubis, on either the right or left side. The so-called left occipito-anterior position is the more frequent. The steps in the mechanism are briefly as follows. First and most essential to a normal mechanism in vertex presentations is thorough and complete flexion of the head on the chest, otherwise malpositions are likely to result, such as brow or face. As the head sinks into the pelvis during the last weeks of pregnancy and is further driven in by the contractions of the uterus, the flexion is increased, so that combined descent and flexion constitute the second stage in the mechanism of a normal vertex presentation. The engagement of the head in the left occipito-anterior position is in the right oblique diameter of the inlet, the long axis of the head engaging thus because this offers the easiest path. It has been found, however, that in a large number of cases the long diameter of the head engages in the transverse diameter of the inlet which however does not interfere as a general rule with the completion of the normal mechanism. As the pains continue the head is forced through the pelvis until it strikes the so-called pelvic floor when the occiput rotates to the front. Whether the rotation of the head precedes that of the back is still an undecided question but the inclined plane afforded by the levator ani muscle undoubtedly influences the rotation of the occiput toward the front. This constitutes the third step in the mechanism of labor. As the pains continue the occiput is finally forced out under the pubic arch and is born. As soon as the occiput is born the shorter arm of the lever has been freed and extension results which allows the face to be swept over the perineum. When the head is born, the face is seen to rotate externally toward the opposite thigh of the mother because the bisacromial diameter at the shoulders has engaged in the opposite diameter at the pelvic inlet to which the long diameter of the head engaged. As the shoulders are propelled by the contractions of the uterus a similar rotation toward the symphysis results so that the bisacromial diameter assumes a vertex position. The anterior shoulder is usually caught back of the symphysis and the posterior shoulder sweeps over the perineum followed after its release by the birth of the anterior shoulder. According to others, the anterior shoulder is delivered first, more frequently than the anterior arm. The trunk is then expelled without any mechanism.

Moulding of Fetal Head.—In order that the child's head may accommodate itself to the passage through the mother's pelvis it is usually necessary for a certain degree of moulding or shaping to occur as the head is ordinarily round and must be converted to a dolichocephalic shape before it can pass through the transverse or oblique diameters of the pelvis. The posterior temporal bone, which in the L. O. A. position is the left, must be displaced under the anterior or right tem-

poral bone. That portion of the scalp which projects through the cervix and is therefore not subjected to pressure becomes the site of a so-called caput succedaneum due to congestion of the venous blood and a serous exudate. In the R. O. A. position the caput is ordinarily over the right temporal bone. In some cases after labor the blood collects under the periosteum to form a cephalhematoma which in contrast to the caput does not transgress the suture lines. The blood is derived from the small venous passages between the periosteum and the bone which are ruptured during labor. This may be due to fissures of the skull resulting after operative, and sometimes even spontaneous labor, as well as to asphyxiation of the child.

Conduct of Normal Labor.—In every labor certain well-accepted forms of procedure must be observed. Such preparations include the patient, the doctor, and the nurse. Preparations for labor on the part of the patient should include the provision of certain essentials which will be enumerated later on. The supplies required may be prepared by the patient herself or a nurse, or if the circumstances permit, they may be purchased ready for use from any one of a number of commercial establishments who provide for such occasions. The conduct of a labor at the present day depends largely on the observation of absolute cleanliness on the part of the patient and everybody and everything that comes in contact with her, especially in the neighborhood of her genital organs. Taking up the preparation of the patient first, it is essential that the woman before labor should be prepared by a thorough cleansing bath with soap and warm water. If the vulva gapes as in multiparæ, it may be advisable to have the patient wear a T-binder with a pad, although this is generally unnecessary. The buttocks, lower abdomen, and thighs should be thoroughly scrubbed and it is advisable to have the vulvar hair either closely clipped or shaved before this cleansing. This precaution will contribute very largely to the comfort of the patient after labor as the lochial discharges are thus prevented from being annoying to her. The bowels in every case should be empty and likewise the bladder, and the best means of securing this is by the administration of a low soap suds enema as soon as the labor pains begin, it being assumed that the patient's bowels have been kept in good condition before this by the administration of suitable cathartics. The examination by the physician should not be undertaken unless the rectum and bladder have been thoroughly emptied, for the accumulation of either fecal matter in the rectum or urine in the bladder will interfere very largely with palpation and likewise the proper engagement of the presenting part of the fetus. As a general rule the bladder can be emptied without difficulty but if this is not possible no hesitancy should prevent catheterization with a soft rubber catheter, observing the usual precautions. The patient should be provided with a loose nightgown and short clean stockings after the bath. It is likewise advisable to have the nurse apply a sterile vulvar pad which may be fastened in the usual method. The presence of the same will aid in the detection of the liquor amnii in case the membranes rupture. The position of the patient in preparing for examination by the physician is rather important. It is essential that the genitals be completely exposed and no attempt should be made to examine the patient under the protection of a sheet, as the hands of the physician should not come in contact with anything before entering the vagina in order to avoid possible contamination. The simplest position for the patient to assume is on her back in bed with the legs partially flexed and the thighs separated, draped with sheets in such a manner that the parts are thoroughly exposed without any unnecessary exposure of the patient. In place of having the patient lengthwise on the bed it is sometimes advisable to have her across the bed with her legs supported on a chair at its side and a sufficient number of pillows under the head and shoulders to make her comfortable. By relieving the tension on the abdominal muscles this sometimes aids in palpation. The lithotomy position and the knee-chest position are occasionally indicated, but as a rule are unnecessary in the ordinary case. A bowl of dilute lysol solution (lysol one dram, sterile water two quarts) with sterile cotton or gauze wipes should be at hand for a final cleansing of the labia before examination. This is done by the physician after his own hands have been carefully disinfected. The simplest and most satisfactory procedure for securing disinfection of the physician's hands is by thoroughly scrubbing them with tincture of green soap and hot water for five minutes, using for the purpose a nail brush which has been boiled. The finger nails should always be closely clipped and all irregularities and hang nails removed. A wooden skewer or nail cleaner affords the best means for removing the dirt from under the finger nails and no metal point should be employed for this purpose as this scratches the inside of the nails and may also wound the skin. After thorough scrubbing for five minutes, the hands are thoroughly swabbed with ninety-five per cent. alcohol for two or three minutes. If possible thin rubber gloves should be worn by the examining physician as these are now easily procured everywhere and may be readily sterilized by boiling for one minute after being wrapped up in gauze or a towel. The use of rubber gloves should not, however, make the physician careless in scrubbing his hands as the possible tearing of the gloves will expose the patient to infection from the skin of the examiner's hands if they have not been thoroughly cleansed. It is not necessary as a general rule to employ a lubricant in examining a patient in labor as a sufficient amount of the natural vaginal discharge is usually present. In the case of primiparæ, however, or women who have been in labor for a long time, the use of dilute lysol solution previously referred to, or one of the lubricating jellies now so generally to be had, is preferable to the employment of vaseline or other greasy substances, as the latter when introduced into the vagina are not readily gotten rid of. Having cleansed the woman's vulva with the dilute lysol solution already referred to, the labia minora are separated with the fingers of the free hand and two fingers of the other hand are introduced vertically into the ostium vaginæ. In this manner the liability of introducing foreign material is largely avoided. At the present time antepartum douches are not generally employed except in the presence of a particular indication as it is recognized that the vagina has a natural protective power which would be inhibited to a large extent by the use of douches. The further steps in the examination of the patient will be detailed later on. It is quite essential that the nurse in attendance should likewise keep her hands clean by washing them thoroughly before assisting the doctor and have all the necessary appliances on hand so that they may be readily reached. In cases where the patient is nervous and irritable or where she has been in long labor it may be necessary to administer an anesthetic before the examination can be satisfactorily made by the physician, and for this purpose the administration of chloroform or ether by the drop method until the primary effect is secured is usually satisfactory. Before this is done, however, the indications to anesthesia in general must be carefully investigated in each particular case.

By means of the vaginal examination in labor, the physician determines the position, softening, dilatation, and abnormalities of the cervix, the condition of the membranes, whether ruptured or unruptured, the character of the presenting part, and the position the latter occupies with reference to the brim of the

pelvis. The cervix is the landmark in the vaginal examination and a careful knowledge of its particular characteristics in each case will usually give a good idea of the stage of the labor. In a normal case at the beginning of the first stage, the cervix may be only slightly dilated and thick; whereas, at a later time it will grow progressively thinner and softer and at the same time will dilate from one finger to a size which will readily admit the passage of the fetal presenting part. The amount of dilatation must be gauged by the fingers when the cervical opening is round. The dilatation of the cervix expressed in fingerbreadths does not refer to the size when the structure is stretched by separating the fingers. In other words, the size of the cervix is measured by the diameter of the same when it is round and not when it has been made elliptical by separating the fingers. In a normal case the membranes will be found to bulge through the cervical opening with each pain and during this time no attempt should be made to introduce the fingers further in order to feel the presenting part as this may result in a permature rupture of the membranes. Between the pains, however, the cervix will usually be found relaxed and then the character of the presenting part may be determined. In a vertex presentation, unless the head is moulded to such an extent that the sutures are obliterated, the posterior fontanelle can usually be felt within the rim of the cervix. It may be recognized by the fact that three suture lines radiate from the same. The anterior fontanelle can be found by following, in an occipitoanterior position, the sagittal suture downward. In a well-flexed head, this anterior fontanelle, which is distinguished by four suture lines running into it, is not always easily reached. If found on the same plane as the posterior fontanelle it shows that the head is not sufficiently well flexed and by pressure on the anterior part during a pain, the flexion of the same may be increased. The diagnosis of position by means of the sutures or the fontanelles is very satisfactory when it can be carried out, but as already stated, the moulding and compression of the head may entirely oblitrate these land-marks. The vaginal examination which has just been described should always be preceded by a thorough abdominal examination, the findings of which can then be confirmed by the former. During the abdominal examination the patient should be flat on her back with the legs slightly flexed, when the physician after having washed his hands thoroughly, makes an attempt to distinguish the various parts of the fetus with the hands applied by their palmar surfaces. The lower segment of the abdomen is first palpated for the head, as the latter is found there in the larger number of cases. The more resistant dorsal plane or back can then be located on either the right or left side of the abdomen and the lower extremities in the opposite upper corner. The fundus of the uterus should also be determined and if the woman is at term it will be found about two handbreadths above the umbilicus with the head engaged in the brim. If the fundus is in this position with the head freely movable it usually indicates that the patient is not at term. Having determined the position of the fetus by palpation, auscultation with the stethoscope should be next resorted to to determine the position of the fetal heart. If the first, or left occipito-anterior position has been determined by abdominal palpation, the fetal heart ought to be heard in the left lower quadrant of the abdomen. These heart sounds must not be confounded with the so-called uterine murmur which is synchronous with the maternal heart beat and is due to the rush of the maternal blood through the large vessels on the surface of the uterus. It sometimes obscures the fetal heart sounds, and if loud, the latter must be looked for with great caution. Auscultation of the fetal heart sounds gives us a very fair idea as to the position of the child and its condition. The average rapidity is about 140 to the minute and male fetuses are believed to present a lower average than females. In using the stethoscope, friction with the fingers may be avoided by the attachment of one or more small rubber bands to the tubes near the receiving end. The fetal heart sounds are double in character and usually sharp. If obscured by a blowing murmur we may assume that some obstruction to the umbilical circulation is present by slight compression of the cord or some other interference with the course of the blood in the same. During the pain the number of beats usually becomes less, but the average rate is resumed when this disappears. The intensity of the fetal heart sounds varies greatly and depends on the position of the child the amount of liquor amnii, and the thickness of the mother's abdominal wall.

The differential diagnosis between the eighth and ninth months of pregnancy may be determined not only by the height of the fetus but also by the circumference of the trunk. The greatest circumference at the end of pregnancy is about 100 centimeters and if this measurement is exceeded, there is a suspicion of multiple pregnancy or hydramnios. This is likewise to be assumed if the circumference reaches these dimensions in the earlier months.

In auscultating for the fetal heart sounds, the entire abdomen should be examined as it is possible to hear two separate and distinct heart sounds which may point to multiple pregnancy. If the latter are heard in two different places and of different rapidity, a diagnosis of this kind is possible. The absence of fetal heart sounds cannot always be accepted as an evidence of the death of the fetus, but if in addition the mother also states that she no longer feels life and the uterus remains stationary or has grown smaller, this may be accepted as conclusive evidence, especially if accompanied by signs of mild toxemia, such as a slight rise of temperature, nausea, and a feeling of fatigue.

Although the conduct of a normal labor can be left largely to the devices of Nature, it is desirable for the physician to be fully acquainted with the various steps of the mechanism so that abnormalities may be readily recognized and corrected if possible. During the first stage, that is until complete dilatation of the cervix results, the patient's uterine muscles are the essential factor in the process. During this period the patient may be up and about or in any other position which aids her comfort. She does not require the assistance of her abdominal muscles at this time and there is no need in advising her to strain with the pains. On the other hand as soon as dilatation of the cervix is complete, the accessory muscles are of value and the patient may occupy a comfortable position in bed with her feet pressed against the footboard or she may sit on a low stool. The latter position is very advantageous in permitting her to approximate her thighs to the abdominal wall and in this way gain additional support in her straining efforts. The various tractors which may be attached to the bed and permit the patient to assist at straining with her arms are usually unnecessary and unless it is desired to distract the patient's attention from her pains, are of comparatively little value. As the head descends through the pelvis and strikes the so-called floor of the pelvis it is advisable to have the patient in bed, as a sudden expulsive effort may cause the head to be rapidly extruded from the vulva with consequent danger of laceration. In England the lateral position is largely employed during the second stage as it is claimed that a better control of the head may thus be secured and less contamination from fecal matter results. As a general rule the dorsal position with the legs flexed will be found more comfortable, however, for both the patient and the doctor and the soiling from the rectum may be largely prevented by a cleansing enema as already referred to. If fecal matter is extruded from the rectum it should always be wiped off away from the vulva with pledgets of sterile cotton

soaked in the dilute lysol solution previously referred to. After the head has reached the pelvic floor and begins to descend, the physician should direct his efforts to keeping the head flexed by pressure on the anterior portion of the same and thus favor the extrusion of the occiput under the pubic arch. By thus keeping the head flexed, premature extension is avoided and in most instances perineal lacerations may be entirely avoided or at least reduced to a minimum. The usually advised pressure on the labia with the fingers is of absolutely no avail at this stage except to tire the attendant. After the head is born, the baby's eyes should be wiped with a piece of sterile gauze from the inner canthus outward in order to remove whatever infectious material may be present from the mother's vaginal secretions. After the head is born it is held in the hand and an examination made of the neck to determine whether any loops of cord are around the same. If so, they may strangulate the child, and this should be overcome by slipping the cord over the head or down over the shoulders as the rest of the body is being born. The anterior shoulder as a rule is born first and after the acromial process slips out under the arch, the head may be gently raised while the free hand protects the perineum. During this time lacerations are very frequently produced and should be guarded against as noted. The remainder of the body is then born without any particular mechanism and the child should be seized by the feet and held with the head down so that any mucus present in the nose and mouth may readily find its way out. Respiration in an ordinary labor is usually spontaneous and no effort should be made to spank or otherwise manipulate the child unless asphyxia is actually present, nor is it advisable to wipe the mucus from the mouth with a dry gauze sponge as this is likely to abrade this delicate membrane. As soon as the child cries readily it may be laid on the bed or on the abdomen of the mother and the period awaited when the pulsations in the cord cease. This permits the child to retain a larger portion of its own blood and also induces collapse of the umbilical vessels. The cord is then tied about an inch away from the umbilicus with a sterile flat tape after the excess of Wharton's jelly has been milked out between the thumb and index-finger. In place of the tape, one of the numerous clips now devised for this purpose may be employed with advantage as the cord seems to dry up much more satisfactorily than in cases in which tape is used. Tearing the cord with the hands or specially devised instruments has also been recommended, but is attended by too much uncertainty to be generally adopted. A dry sterile dressing is now applied to the cord and this held in place with an abdominal binder of gauze which must be loosely applied and fixed with stitches instead of pins. The baby may now be turned over to the care of the nurse. During this period, however, the physician's attention must be constantly directed to the mother's uterus as hemorrhage is very likely to occur during this time. The expulsion of the placenta which marks the completion of the third stage may be awaited for. No definite time limit can be placed on the delivery of the placenta although in the majority of cases the pains begin within a half hour or less after the delivery of the child or can be initiated by gentle massage if the uterus seems soft. The placental delivery must be conducted with considerable caution and after it is extruded from the vagina, the membranes should not be twisted but delivered without this manipulation. Immediate examination of the placenta and its membranes is essential and if any placental remnants or a succenturiata is diagnosed it may be necessary to explore the uterus for the same. If pieces of membrane are found to have been left adherent, however, it is advisable not to go after them except in the presence of a hemorrhage, as they will usually be expelled spontaneously within twenty-four hours. In those cases where the placenta is retained in whole or in part it may be necessary to extract the same with the hand. In such cases the operator's hands must be most carefully disinfected and fresh gloves employed. After cleansing the patient's external genitals the hand is carefully inserted through the cervix and the interior of the uterus freed from the attached placenta, great care being taken not to push the finger through the uterine wall. This may be controlled by the free hand being placed on the abdomen.

Hemorrhage in normal cases of labor does not usually exceed twelve ounces but as there is a possibility of bleeding in every case the uterus should be carefully watched by the operator or the nurse for at least an hour after delivery. Massage of the fundus as generally practised is unnecessary. The uterus alternately contracts and retracts under normal conditions and it is merely essential for the attendant to note whether the retraction extends beyond normal bounds. The fundus of the uterus after the third stage should be at or near the level of the umbilicus. If it goes above this and the substance of the organ is found to be soft, gentle massage should be resorted to until a firm contraction is obtained, when the rubbing must cease. As the bleeding when present may not necessarily be from the uterus itself, but from the cervix or vagina, too much time must not be lost in efforts at obtaining contractions of the uterus, for this is perhaps not at fault. The subject of hemorrhage is more fully discussed in the article devoted to that subject.

Anesthetics in Labor.—The administration of anesthetics in normal labor is regarded as a routine practice by many physicians but under ordinary circumstances it may very well be done away with. Chloroform is with justice regarded as an ideal drug for this purpose as its administration can be readily graduated and if given in reasonable amounts it has but little if any, permanent effect on either mother or child. In certain cases toward the end of the period of dilatation, the intermittent administration of a few drops of chloroform on an open mask will do much to alleviate the painful character of the contractions, which is often marked in certain women. Caution must be exercised to use only a very small amount of the anesthetic and its continued administration must be governed by careful observations of the pulse and the color of the patient. Sometimes the mere odor of a drop or two of chloroform will afford the patient a feeling of relief and thus an excellent placebo is provided. As the head descends to the perineum a somewhat larger amount of chloroform may be given in order to diminish the force of the expulsive efforts but in many cases with a proper control of the perineum by the hand of the physician, this is not necessary. The administration of chloroform should never be left to any inexperienced person and it is a great mistake to allow the husband or other unskilled attendant to administer this agent, especially during the excitement which usually attends the final stages of a labor. Although chloroform is usually regarded as the ideal anesthetic, the complications attending its use must be carefully borne in mind, as a sudden stoppage of the heart and respiration is likely to occur in any case, and before beginning the administration of the drug the possibilities of such complications must be noted. Mention might also be made at this point, although the subject belongs to another chapter, of anesthesia in operative deliveries. It has long been the custom at the New York Lying-In Hospital to employ ether in every case where a prolonged anesthesia is necessary; such as in forceps extractions, versions, and other operative procedures, for the administration of the same is accompanied by much less danger to both mother and child. It must not be forgotten that in every instance where an anesthetic is administered, the effect on the child is usually manifest and must be borne in mind when resuscitating the same.

Nitrous oxide-oxygen sequence has been recommended as a routine procedure in labor cases but has not met with extended favor. Mixtures of chloroform and ether as well as chloroform and oxygen are also of value as the amounts of the separate ingredients are relatively small for the production of the desired effect. A great deal of attention has recently been attracted to the subcutaneous injection of narcotics, especially scopolamine and morphine. This produces the so-called "twilight sleep" and has been largely employed in certain European clinics. It consists in the administration of an average dose of 0.3 milligram of scopolamine with 1 centigram of morphine, narcophine, or other derivative of opium at the beginning of labor. The scopolamine is repeated at definite intervals depending upon the patient's response to the memory tests. This must be done in an absolutely quiet room, the patient not being disturbed by outside noises. It is claimed that the entire labor may be conducted without the patient being aware of any painful sensations, but in view of the great skill and attention necessary in its administration and the possibility of asphyxia of the infant, the method will probably not be suitable for general employment. A valuable adjunct in the conduct of prolonged labors is the administration of morphine by hypodermic in ⅛- or ¼-grain doses, where the patient is worn out by continued pains, the cervix is not dilating readily, and exhaustion is imminent. In such cases the morphine has a quieting effect on the patient, produces an hour or two of refreshing sleep at the end of which the patient is again able to take up the work.

Lacerations of the Cervix and Perineum.—After the child is born and before the placenta is delivered an inspection should be made to detect the presence of perineal lacerations. At this time the hemorrhage is less than after the placenta is born and while waiting for the delivery of the latter, perineal lacerations, if present, may be readily repaired. The patient's external genitals must be fully exposed in a good light and after the hands have been carefully disinfected, the labia are separated and with a sponge wrung out in the antiseptic solution used in the particular case, an inspection is made for the purpose of determining the character and extent of any lacerations that have resulted. It is advisable to repair the same immediately by means of sutures introduced in such a manner that the torn muscular fibers are restored as far as possible to their normal relations. Under ordinary circumstances the results of such repairs are exceedingly good. The materials needed for the repair of such lacerations are suitable needle-holders and a number of curved needles, some of which have round and others sharp points. The round-pointed needles threaded with No. 1 chromic or plain catgut are used for the internal sutures and the sharp-pointed needles threaded with silk or silkworm gut for those sutures that have to pass through the skin. For the introduction of the sutures immediately after the delivery of the child, anesthesia is seldom required as the parts to be manipulated are dulled from the pressure of the dilating fetal mass. The commonest situation for perineal lacerations is in either vaginal sulcus and it is essential to introduce the sutures into the upper portion of these tears. Interrupted sutures are preferable and the thinner catgut is recommended as absorption is more rapid. In introducing the sutures which approximate the skin surface, care must be taken not to obstruct the lochial discharges by forming a dam across the opening. The external sutures of silkworm gut or silk are best united in a single strand by a knot about two inches away from the skin. This procedure serves to facilitate the removal of the stitches. In every case where a perineorrhaphy has been done, the vulva should be irrigated with sterile water or dilute (1:1,000) lysol solution by the nurse after every urination, as by this means the line of sutures will be kept clean and free from the probability of infection. The repair of the perineum at this period of the labor has the disadvantage of interfering with a possible laceration of the cervix although immediate repair of cervix lacerations had in most cases better be omitted unless the hemorrhage from the same is extreme. Such hemorrhage, however, is already noted before the delivery of the placenta and if the uterus is well contracted and free bleeding still takes place, it is very apt to come from this source. An inspection can then be made and if an extended tear of the cervix is present, the suturing of the perineal tear can be postponed until after the delivery of the placenta and the suturing of the cervix. If it is found necessary to repair the cervix, sutures of No. 1 or No. 2 chromic catgut (ten day) introduced with a round-pointed needle and including the muscular layer down to the mucous membrane, may be inserted, but they should not be carried too far toward the position of the external os and thus interfere with proper drainage. It may be safely stated that cervical lacerations of a slight degree, not accompanied by hemorrhage had best be disregarded, as their extent is very much exaggerated during the period after delivery, when the cervix is soft and friable.

Douches after Labor.—It was formerly customary to administer a postpartum douche in every case but this has been abandoned as a routine procedure at the present time and is considered unnecessary. Where a labor has been prolonged, however, or operative delivery found necessary, or the uterus does not contract satisfactorily, the administration of a four-quart douche of sterile water at 110° F. will do much to wash away possibly infectious material. The douche must be given under the most careful asepsis, however, and had better be omitted unless such a procedure can be followed.

Care of the Patient after Labor.—Labor may be regarded as a process that subsequently requires rebe on the part of the patient and therefore as soon as ths placenta has been delivered, quiet should be insisted on. The fundus of the uterus should be watched for a period of at least an hour after delivery of the placenta to guard against possible postpartum hemorrhage as already referred to. At the end of an hour it is advisable to gently massage the uterus sufficiently to expel any blood clots that may be present in the same, after which a sterile vulvar pad is applied, together with a moderately firm abdominal binder of muslin that extends from the line of the trochanters of the femora to the chest. The wearing of an abdominal binder affords the patient a great deal of relief during the first day or two after labor but may safely be discontinued at the end of forty-eight hours. It should not be pinned on so tightly that it interferes with movement or induces a possible retroversion of the uterus. The baby may be safely given the breast at the end of four hours after labor for the efforts at suckling will aid in the contractions of the uterus. The further care of the mother and infant will be found discussed in the article on the *Puerperium*.

B. The Pathology of Labor.—The dividing line between the abnormal and normal in labor is frequently a difficult one to draw, but generally speaking we may regard all cases as abnormal in which the progress of the labor is halted or interfered with by factors which present themselves on the part either of the mother or of the child. Operative delivery for the purpose of hastening spontaneous labor is indicated in the presence of danger to either the mother or child. It is convenient to classify the various disturbances during labor in the following manner

I. Dystocia due to disturbances in the mechanism of labor, in which the progress of the delivery is halted or interfered with. Among these disturbances we may include

1. Anomalies of the expulsive forces: weak pains, insufficient action of the abdominal muscles, tetanic contractions of the uterus.

2. Abnormal resistance: (*a*) on the part of the mother by closure or narrowing of the maternal birth canal in either the soft parts or the bony pelvis; (*b*) on the part of the child by abnormal position or attitude, abnormal size, monstrosity, and in rare cases by a short cord.

3. A combination of strong pains and energetic abdominal contractions together with diminished resistance of the maternal birth canal and the child may result in a rapid or precipitate delivery.

II. Dystocia due to factors which are independent of the mechanism of labor: (1) eclampsia; (2) hemorrhage; (3) inversion of the uterus; (4) prolapsed cord; (5) air embolism.

Weak pains or uterine inertia may be primary or secondary. Primary uterine inertia is found associated with general constitutional weakness in patients suffering from chlorosis or those emaciated by disease or lack of food, likewise in women who have been subjected to rapidly succeeding pregnancies without proper care, in generally contracted pelves and in very young or very old primiparæ as the result of insufficient development of the uterine musculature, in abnormal distention of the uterus from the presence of twins, hydramnios or tympanites, the presence of tumors of the uterine wall and with an overdistended bladder or rectum. Weak pains are of consequence only after the membranes have ruptured, and during the first stage comparatively little attention need be paid to the complaints of the patient. In the presence of general weakness, stimulants and food, together with the insistence on quiet, are indicated. If the patient is excited, the administration of narcotics is desirable, care being taken in their administration. A few drops of chloroform on an open mask at intervals, especially where cramp-like pains are present, is very efficient, as already referred to. If the attending physician is unable to administer the chloroform, an eighth or a quarter grain of morphine by hypodermic may be substituted. The bladder and rectum must always be thoroughly emptied. In the presence of hydramnios it may be necessary to rupture the membranes artificially before the cervix is fully dilated, but this should be done during the interval between the pains and as far as possible from the cervical opening so that the cord is not displaced with the rush of the waters.

Secondary uterine inertia results from the presence of an abnormal degree of resistance in either the soft parts or the bony pelvis. This condition must be recognized and treated in order to avoid the possibility of lacerations of the lower uterine segment, the cervix and the perineum. This often results in the uterus being reduced to a state of almost tetanic contraction with the lower uterine segment tightly applied to the presenting part. If the condition of the fetus demands interference the latter is sufficient indication for immediate delivery. If not, and the possibility of spontaneous delivery is still present, the exhausted uterus should be put to rest by the administration of morphine in eighth or quarter grain doses by hypodermic. Prolonged labor from this cause frequently requires operative interference, particularly if the membranes have been ruptured for a considerable time and no progress in the dilatation of the cervix or the advance of the presenting part results.

A patient in this condition is moreover more liable to septic infection. Intrauterine death of the fetus frequently results in cases where the membranes have been ruptured a long time and the labor halted by atonic contractions of the uterus and a diminution in the size of the uterine vessels and a consequent lack of sufficient oxygen for the fetus. Tetanic contractions of the uterus are merely a further stage in secondary uterine inertia, in which the ute us is closely applied to the fetus so that the hand cannot be introduced between the latter and the uterine wall. There is no interval between contraction and relaxation and the patient may experience a continuous pain. Causes of tetanus of the uterus include resistance which cannot be overcome, such as a narrow pelvis or a transverse position, unsuccessful attempts at delivery, and attempted manual dilatation of the cervix. As a muscle in a state of continuous contraction cannot accomplish any work, the labor is halted and in such cases a rupture of the uterus is not infrequent, commonly resulting in the death of the patient from sepsis or exhaustion. The children in such cases usually die from asphyxia. A true tetanus cannot be overcome by the injection of morphine and other narcotics. Immediate delivery in such cases is indicated, but should not include version, as the introduction of the hand is interfered with by the absence of the liquor amnii and the application of the uterine wall to the fetus. If a transverse position is present evisceration or craniotomy is indicated. As the presenting part may be hard to reach and the cervix insufficiently dilated this may be difficult and even in the presence of a dead child cesarean section may be the most suitable procedure if it is possible to transport the patient to a hospital. If the head presents and is engaged, forceps extraction may be resorted to if the child is alive, but if not, perforation of the head is indicated. Where no engagement has taken place perforation may be necessary even with a living child. The placenta should be removed as soon as possible and the uterus after such an operation is preferably douched with several quarts of sterile water or a half per cent. lysol solution.

Closure or Narrowing of the Maternal Soft Parts.—Obstruction to labor from closure or insufficient dilatation of the cervix may be due to simple rigidity but is occasionally an actual atresia or agglutination which may have come about during pregnancy. Notwithstanding strong pains the cervix does not dilate and the lower uterine segment is excessively distended by the presenting part. A secondary uterine inertia results or the cervix is torn loose from its attachments to the lower segment of the uterus. A closure of the cervix may be also simulated by an abnormal position of the latter, which in some cases is high and posterior. This condition is not uncommon in primiparæ and is also associated with cases in which operative procedures have been undertaken for the relief of a retroversion or prolapse and an adhesion between the anterior wall of the uterus and the abdominal wall has resulted. In cases of simple rigidity or agglutination, dilatation with the finger is usually sufficient to start the process. In the presence of atresia, however, crucial incision of the cervix may be required. If this is not sufficient, dilatation of the cervix with the fingers up to a diameter of two or three inches may become necessary and occasionally if the cervix is not well softened or shortened, the introduction of the smaller sized soft rubber bags may be necessary to initiate the process. In some cases the cervix remains long as the result of insufficient softening or in occasional cases, the presence of malignant disease. Mechanical dilatation by the metal dilator, followed by the introduction of soft rubber bags, should be practised or in cases where malignant disease is present, a cesarean section may be necessary.

In a certain number of cases adhesions between the maternal and fetal membranes in the immediate vicinity of the internal os are so marked that the lower segment does not retract and consequently the cervical canal does not dilate. In such cases the introduction of the finger and loosening the membranes is usually sufficient to bring about beginning dilatation.

Closure or narrowing of the vagina or vulva may be congenital resulting in annular stricture, or acquired. In the latter case cicatricial bands or adhesions may have followed ulcerative processes as the result of previous difficult labors, infectious diseases, etc. During the course of the labor in such cases, the

dilating effect of the presenting part must be observed. If this stretches the adhesions nothing further is necessary, if not, the latter must be incised. Where the narrowing or closure is not overcome by this means, abdominal cesarean section may be necessary. Abnormal rigidity and narrowing of the vagina and vulva are frequently seen in very young or old primiparæ and should be subject to expectant treatment until all indications for ending the labor presents. If the head has advanced to the pelvic floor and delivery is immediately indicated, an incision of the vaginal outlet may be made in the region of the perineum.

Closure or narrowing of the soft parts by neoplasms or tumor-like masses include:

1. Overdistended bladder and rectum, which must be corrected by emptying these organs with the catheter or by enema.

2. Vesical calculi are often sufficiently large to interfere with the delivery of the child and if they cannot be pushed out of the way, must be removed through the vagina, the wound in the bladder being sewed up before completing the delivery.

3. Uterine myomata. Polyps which interfere with the delivery of the child should be removed after ligaturing the pedicle, and myomata situated in the cervix or lower uterine segment must in certain cases be enucleated before delivery can be completed. Large deep-seated myomata in the body of the uterus are often displaced upward by the contractions of the organ and allow the passage of the fetus. In other cases, however, they interfere to such an extent that a laparotomy with excision of the tumor or of the entire uterus is necessary. The child in these cases is of course removed by cesarean section.

4. Carcinomata are less apt to interfere on account of their size than on account of the rigidity of the cervix which they produce.

5. Ovarian tumors may often be pushed up out of the way of the advancing fetus, but if not, they must be removed by the vaginal or abdominal route, depending on the situation. In some cases they descend into the posterior vaginal vault and can be readily excised after incision of the latter. If the growth is cystic and there is immediate danger to the mother a vaginal puncture may be undertaken, the patient delivered, and then ovariotomy completed by the most suitable method. In some cases it may be necessary to remove the tumor through the abdomen and then delivery may be completed immediately or delayed, depending on the particular case. Tumors of the pelvic cellular tissue or the pelvic bones which complicate delivery must be extirpated or cesarean section may be resorted to.

Contracted Pelvis.—In so far as we are concerned with the relations of pelvic deformities to labor, it is merely necessary to recognize here the commoner varieties. These include the generally contracted pelvis which is diminished in all its diameters, the simple flat pelvis in which the antero-posterior diameter is contracted, the generally contracted flat pelvis which combines the characteristics of the two previous varieties, the obliquely contracted pelvis in which one oblique diameter exceeds the other by several centimeters, various other forms of irregularly contracted pelves associated with Pott's disease, rickets, osteomalacia, and finally the funnel pelvis. The discussion of the anatomical features of these various pelvic deformities may be found in the section on the pelvis. It is essential that the variety of pelvic deformity be diagnosed before labor. When labor has come on, however, and an obstruction is present it is necessary to be informed as to the particular variety in order to afford the patient the best method of delivery. The possibility of contracted pelvis is associated with the following general characteristics: small stature with deformities of the spinal column, a limping gait, deformities of the lower extremities which are usually manifested by bow-legs or knock-knees from early rickets, pendulous abdomen in primiparæ, severe and prolonged previous labors and deviations from a normal physiological course. The latter include premature rupture of the membranes, prolapse of the cord or the extremities, non-engagement of the head in the brim of the pelvis, the assumption of an abnormal attitude on the part of the mother, and the manner in which the head engages. Thus in a flat pelvis the large anterior fontanelle and frontal sutures are at the most dependent point. In a generally contracted pelvis the small posterior fontanelle is markedly low and in generally contracted flat pelvis the frontal suture is prominent and likewise the small fontanelle. The engagement of the head noted in the latter is to be regarded as the most favorable position for the passage of the head through the contracted pelvis. The prognosis in pelvic deformities depends on the degree of the contraction, on the strength of the pains and the activity of the abdominal muscles, on the size and hardness of the fetal head, and on the engagement of the latter. It is for this reason that subsequent labor may prove unfavorable in narrow pelves when the first labor may have been successful without interference. The dangers for the mother in these cases may be summarized under the following headings: Prolongation of the labor with the possibility of infection and hemorrhage, contusion and necrosis of the soft parts with a possibility of fistulous communication with the bladder, and the fracture of the pelvis, ordinarily through the symphysis. The dangers for the child reside in the possibility of asphyxia on account of the prolonged labor or the abnormally marked pressure on the skull.

The question of treatment in deformities of the pelvis depends entirely on the particular variety encountered and on the possibility of the child adapting itself to the canal. In the flat pelvis four varieties of contraction have been enumerated. In the first the true conjugate measures from 8.5 to 9.5 cm., in the second from 7 to 8.5 cm., in the third from 5.5 to 7.5 cm. and in the fourth less than 5.5 cm. In pelves which manifest the fourth degree of contraction, cesarean section is alone to be considered as even a perforated full-term child cannot be born through a pelvis of this size. In the third degree there is a choice between cesarean section and perforation, unless the mother is very desirous of a living child. In contractions of the first and second degree, good strong pains, a small moderately hard head, and favorable engagement of the same may result in the spontaneous delivery of a living child. In many cases, however, version, forceps, or cesarean section may become necessary. In certain cases of moderate contraction where the true conjugate measures from 7 to 8 cm., induction of labor in the last month of pregnancy has been recommended and where no operative facilities are at hand for a possible cesarean section or other operation, this form of delivery may become necessary. If version is decided on in this class of cases it should be done as early as possible, before the mother is exhausted or the liquor amnii drained away, otherwise the dangers of infection or uterine rupture are greatly increased. The advantage of version consists in the belief that the aftercoming head may be more readily forced through the pelvis because greatly increased traction force can thus be exerted. The latter is favored by Walcher's position. The procedure of version will be fully discussed under its appropriate heading. In cases where it is attempted and the head cannot be delivered, perforation of the latter may become necessary. In cases of vertex presentation when the head is firmly engaged in the pelvic inlet, an expectant plan may be adopted if the mother and child are not in danger. Compression above the symphysis sometimes aids the engagement of the head and likewise those measures already referred to in the treatment of uterine inertia. When the head is fully engaged the application of forceps is indicated, but it is advisable

not to attempt the same before moulding has advanced to a sufficient degree. If the forceps operation is unsuccessful and the child is still alive, pubiotomy may be considered before perforation. The good results obtained with the extraperitoneal form of cesarean section has also brought this operation into the field for the delivery of these cases.

In cases where the pelvis is generally contracted in all its diameters an expectant treatment may be resorted to if the head is well engaged, followed by the application of the forceps when indicated. Perforation must be considered where the head does not engage thoroughly notwithstanding pressure from above, and danger results from the extreme dilatation of the lower uterine segment which will be found in these cases. In patients in whom previous labors were unfavorable the premature induction of delivery and cesarean section are both to be considered.

In cases of funnel pelvis the division of the pubic bone has frequently been resorted to within recent years, especially when the head is well engaged and the patient has been in labor for a long time. Where this is complicated with a posterior position of the occiput, a cesarean section frequently offers better results. In obliquely contracted pelves of a marked degree the delivery is often accomplished without apparent difficulty, but where interference occurs the same methods may be resorted to as in previous cases.

In all cases of suspected pelvic contraction the vaginal examinations must be undertaken under the most careful auspices as the possibility of operative interference naturally increases the danger from infection. Pregnant women who present a pelvis with a true conjugate of eight centimeters or less are preferably delivered in a hospital and the same is true of those cases of even slight contraction in which previous labors have been difficult. In other cases where the pelvis presents only slight degrees of narrowing and no indications for immediate delivery are present, the expectant plan may be adopted. If the head after rupture of the membranes and notwithstanding strong pains does not engage in the pelvis, and no other danger to mother or child is present, the methods referred to in the previous sentences are to be followed. The perforation of a living child in the interests of the mother or the perforation of a child dead from prolonged labor are factors that are gradually being eliminated from obstetrics. The attendant under these circumstances is under moral obligation to refer the patient to a hospital in which the delivery may be completed by appropriate operative measures which under most circumstances are much less dangerous for both mother and child than a version or a high forceps operation done in the home.

Disturbances of Labor due to Anomalies on the Part of the Fetus.—These consist as already stated in abnormal position or attitude of the fetus, increase in the size of the head, the shoulders, or the trunk, and malformations, especially duplications. The transverse position with prolapse of the arm is best treated by complete internal version. It is of course possible for a fetus in a transverse position to be delivered spontaneously, but as its death usually results it is better to resort to operative delivery in these cases. In the presence of an occiput posterior position the conduct of the labor depends entirely upon the individual case. Very often the posterior occiput will be rotated to the front when it strikes the pelvic floor and flexion can be maintained or it may be delivered as such without undue danger. A persistent occiput posterior position frequently requires the application of forceps, but under ordinary circumstances anterior rotation of the head should never be attempted with the head in the pelvis. If an occiput posterior position is recognized with the head in or above the brim, its anterior rotation may be safely attempted.

Face presentations with the chin directed anteriorly or posteriorly should be diagnosed before firm engagement has taken place as they may then be corrected by flexion of the chin on the chest, or what is preferable, a version may be attempted. If the chin is directed posteriorly, labor is practically impossible and in such cases if it is too late for version, perforation should be resorted to. The same applies to brow presentations.

In cases where the arm or leg prolapses alongside of the head, the limb may be replaced but if unsuccessful, version should be attempted as these conditions usually are present in slight degrees of pelvic flattening.

In the presence of a large head, engagement in the pelvis is necessarily slow and if unsuccessful, version may be resorted to as the aftercoming head frequently engages much more readily in this way. If unsuccessful, perforation may be resorted to. The diagnosis of abnormal size of the head is based largely on exclusion but care must be taken to differentiate this from a hydrocephalus which is recognized by the broad sutures and large fontanelles. If a hydrocephalic head does not engage, perforation is usually indicated. The shoulders may be very large in cases where the head is normal and in such instances their engagement may require assistance from the operator's finger or a blunt hook inserted into the posterior axilla. Fracture of the arm may even be necessary in difficult cases and is allowable in order to hasten the labor. If the child is dead it is advisable to decapitate before extracting the trunk.

Abnormal engagement of the trunk may result from the presence of hydrops, emphysema, or various tumors. The diagnosis in these cases may be very difficult and if the trunk cannot be extracted after the arms are delivered the complication must be considered. Puncture of the fluid-containing sac is essential before any further measures can be made use of. Labor may be delayed by the presence of twins and if a version becomes necessary for delivery or a breech extraction is indicated, great care must be taken that the heads of the children do not lock. The presence of monstrosities is usually diagnosed with difficulty and frequently exploration with the hand in the uterus under an anesthetic is necessary.

Precipitate Labor.—This results from a combination of favorable factors, including strong and frequent pains, accessory pressure with abdominal muscles, diminished resistance on the part of the mother and the child. Under such circumstances the entire course of labor may occupy only a few minutes. More frequently, however, it is only the period of expulsion which is abnormally quick, whereas the pains during the period of dilatation may not be evident to the patient. Such rapid deliveries only become pathological when they result in perineal lacerations or injury to the child if the latter is dropped and the cord is torn or the fetal skull injured by the fall. Moreover, complete atony of the uterus may result in such cases, with inversion and the danger of severe hemorrhage. If a patient is carefully watched, in most cases precipitate labor need not occur as the head may usually be held back with the hand or the patient directed not to strain and to keep her mouth open. When possible a few whiffs of chloroform may be administered to reduce the involuntary efforts on the part of the mother.

Preparations for Confinement.—The preparations for this event on the part of the patient will vary according to her financial ability. Specially fitted boxes containing sterilized supplies may be obtained in almost all large cities from the druggists' or hospital supply houses but very often it is necessary for the physician to supply the patient with a list of necessities for the confinement. It would be better perhaps if the doctor carried his own supplies as this avoids misunderstanding on the part of the patient and the attendant can be assured of having the necessary materials properly selected and sterilized. In the obstetrical bag used by the writer for a considerable

period the supplies noted below, are contained. Individual preference may of course dictate others or the case itself may seem too bulky, but in view of the possibility of unforeseen complications the writer has found it advisable to adhere strictly to this list. A suit case of black oilcloth or leather about 12 inches wide, 24 inches long and 8 or 10 inches deep, provided with a tray, will be sufficiently large to include the following paraphenalia: six towels, gown leggins, cord dressing, two pairs of forceps including an axis-traction instrument, perineorrhaphy set, cord, scissors, and tape, douche bag, two douche tubes, catheter, two pairs of rubber gloves, six vulvar pads, nail brush and cleaner, hypodermoclysis set, hypodermic needle and syringe, Kelly pad, rubber apron, canvas leg holder, baby scales, agate basin of four-quart capacity, two gauze bandages (three inch), chloroform mask, chloroform, one per cent. solution of silver nitrate, acetic acid, fld. ext. ergot or 'ergotole,' boracic acid, salt solution, alcohol, bichloride tablets or lysol, camphor in oil, nitroglycerin, morphine, caffeine, pituitrin, stethoscope. It is not ordinarily advisable to rely on the finding of the necessary supplies in a patient's house if called in an emergency and if the doctor is familiar with the contents of his labor bag a great deal of time and annoyance may be saved. The writer is moreover in the habit of giving his patients as soon as they apply for care during their confinement, a little manual which contains an account of pregnancy and labor, together with directions for the hygiene of pregnancy and the preparations for the labor itself. In this way the patient is able to digest the directions at her leisure and a great many questions will be found unnecessary. In this pamphlet the following supplies are noted and left for the patient to procure: two enameled wash basins of about four quarts' capacity and an enameled pitcher of a two-quart size. A wash boiler of medium size in which these may be boiled and which will also furnish a supply of sterile water. The basins and pitcher together with two ordinary nail brushes should be boiled in the wash boiler one-half full of water for at least thirty minutes and then allowed to cool off. In addition to this the patient is asked to select a room in a quiet portion of the house or apartment, provided with windows leading to the outer air. She is directed to have removed all articles of furniture with the exception of the bed, and a table or bureau. The carpet should be taken up and the floor and walls together with the window- and door-trim thoroughly cleansed. As most beds are rather low a number of wooden blocks or bricks should be at hand to insert under the bed-posts during labor so as to raise the bed to a height of about three and one-half feet from the floor. This will give a great deal of comfort to the doctor and nurse during their attentions to the patient. The sinking in of the ordinary spring mattress also produces a most inconvenient hollow in the bed which may be overcome in most cases by having a number of boards or leaves from an extension table inserted under the mattress across the bed. Two rubber sheets should be provided, one of which is placed next to the mattress and this covered with a plain white sheet on which a second rubber sheet and plain white sheet are placed, so that after the labor is over the upper rubber sheet may be removed and the mattress still remains protected by the lower rubber and sheet. Several half-pound packages of sterilized absorbent cotton will be needed, one of which is to remain closed for the doctor's exclusive use; the others may be used by the nurse for making vulvar pads and wipes. A supply of sterile gauze will be needed and the most economical purchase is in the form of rolls containing either twenty-five or one hundred yards. Pads to be worn after labor should be made from this gauze and absorbent cotton by the nurse in ample time and may be sterilized by steaming in an Arnold bottle sterilizer or by whatever means are at hand. At least four dozen vulvar pads should be provided before labor, packed up in muslin packages of three each. Prescriptions should be given by the physician for the following drugs: lysol, four ounces; gram alcohol, one pint; tincture of green soap, one-half pint; boracic acid in crystals, four ounces; white vaseline in tubes, castor oil and glycerin, talcum powder, small nursing bottles and nipples, enema bag or a metal douche can with six feet of rubber hose, connecting tube and a soft rubber rectal tube, douche pan of enameled ware which may also be used as a bed-pan, scales for weighing the baby, and a number of manila paper bags for receiving waste.

In engaging a nurse for a confinement case, care should be exercised to obtain one who has had a satisfactory obstetric training and the patient must be impressed with the value of a good nurse and be willing to pay her a suitable fee. Cleanliness, common sense, and ability to deal with emergencies are qualifications demanded of a nurse who essays to take a case of labor. A knowledge of these qualities ought to be known to the physician in attendance and the selection left if possible to him. It is well to engage a nurse to come to the patient's house at least four or five days before the expected date on which the patient is to be confined so that all necessary preparations for labor may be made without haste. In a normal uncomplicated case a nurse should be retained for at least two weeks after labor and it is advisable if the patient's circumstances permit to keep her a week or two longer, for during this period the patient is in need of all the rest she can get and should avoid all undue exertion and excitement. It is unnecessary to refer again to the necessity of absolute antisepsis on the part of the nurse and physician during a case of labor and one's mind should be made up to regard this process as similar to the invasion of the peritoneal cavity in a laparotomy. It is only when the conscience of the physician acknowledges this that he can be free from mental anxiety in case the affair does not turn out as expected.

Mechanism of Labor in Abnormal Presentations and Positions.—In addition to a knowledge of the mechanism of labor in the so-called normal positions and presentations, namely, where the vertex presents with the occiput turned to the front, a knowledge of the possibilities of natural delivery in other cases is essential. Such labors are, of course, abnormal, yet the natural resources on the part of the patient may be successful in accomplishing the delivery of the child. The indications for interference should be carefully noted, however, and the necessary steps taken when the occasion arises. The principal factors relate to the exhaustion of the mother or damage to her soft parts by the prolongation of the labor and the latter, of course, effects the child particularly as regards asphyxia.

The commonest abnormality in engagement is the *occipitoposterior position* in which the anteroposterior diameter of the child's head is directed in the opposite direction from the anterior position. This almost always results in a prolongation of the labor and the formation of a caput succedaneum or possibly a cephalhematoma. Fortunately a very large proportion of occipitoposterior positions of the vertex rotate to an anterior position either above the brim, in the cavity of the pelvis, or when the head reaches the vaginal outlet. In other cases the occiput remains posterior and the face is born under the pubic arch. The long diameter of the head does not conform satisfactorily to the axis of the pelvis and sometimes an absolute cessation of labor results from impaction. The most frequent causes of the anomaly are imperfect flexion of the head so that occiput and sinciput reach the pelvic floor at the same time, failure of the mechanism which ordinarily turns the occiput forward, defective resistance due to previous lacerations of the pelvic floor, large pelves and pelvic abnor-

malities including contraction, faulty inclination, obliquity, and kyphotic deformities. It is essential to make the diagnosis of occipitoposterior position as early as possible so that the same may be converted to a normal and more easily delivered position. Abdominal palpation shows the dorsal plane directed toward the flank of the mother and the soft parts are felt under the anterior abdominal wall. The heart sounds are usually heard over the side of the abdomen toward the back or may be absent. A vaginal examination shows the anterior fontanelle readily accessible to the finger, occupying either an occipitoposterior position or a poorly flexed anterior position. The posterior fontanelle is then reached with somewhat greater difficulty and felt opposite the sacroiliac synchondrosis. The dangers in these cases to the mother consist in the increased possibility of perineal lacerations, general exhaustion, and the risks of operative interference. To the child, the prolonged labor is readily productive of severe asphyxia. It is usually found that the membranes rupture early in occipitoposterior cases with the bad results following this accident. A diagnosis having been made, the treatment depends on the position of the head. With the latter above the brim and the membranes unruptured the patient should lie on her side with the hips elevated in a position so that the occiput faces the side on which she lies. Flexion and engagement are thus favored and anterior rotation of the back commonly results. The knee-chest position is also efficient but difficult to maintain because it is tedious to the patient. If these methods are unsatisfactory attempts may be made to rotate the anterior shoulder through the abdomen, if this can be felt, while the fingers of the vaginal hand push the anterior shoulder in the opposite direction. It is often impossible, however, to rotate the head and maintain it in an anterior position. Where engagement does not seem likely to occur a podalic version may be resorted to.

When the fetal head is in the pelvic cavity, anterior rotation of the occiput may also be favored by keeping the patient on the side toward which the occiput points. The maintenance of flexion by pressure against the sinciput during pains often aids rotation in these cases. Where the head is sufficiently small to permit the same the hand may be passed into the vagina or lower uterine segment following complete dilatation and the head flexed and rotated to the front. Rotation of the fetal head with the forceps is a particularly dangerous procedure and should not be attempted by any one but an expert, on account of the dangers of laceration with the instrument. At the vaginal outlet, anterior rotation is often satisfactorily accomplished by pressure against the anterior temporal bone. In a certain proportion of cases where the head has reached the perineal floor and the pains are good, it is safer to allow the posterior occiput to be born as such than to attempt unskilled interference.

Face presentations are due to extreme extension of the head on the trunk and have been estimated to occur once in twenty labors. The chin may be directed either anteriorly or posteriorly, the latter being the more common. The causes of face presentation are narrow pelvis, large child, enlargement of the neck or thorax, extensive uterine obliquity, multiparity, pendulous abdomen, malformations of the child's head, and paralysis of the extensor muscles on the anterior side of the neck. In the mechanism of these labors the occipitomental diameter comes into relation with the axis of the birth canal and the head descends with the chin first, the trachelobregmatic and bitemporal diameters engaging at the brim. Although the latter are substantially the same length as those associated with vertex presentations, the difficulty, especially in cases where the chin is directed posteriorly, is due to the fact that the thickness of the neck and a part of the chest are added to the diameter of the face as it presents at the brim. In mentoanterior positions the mechanism is as follows: expulsion of the head corresponds to flexion in vertex presentations, although this is never fully developed until the face has passed the brim. As the head descends the chin rotates under the pubic arch and is born. This maneuver is followed by flexion of the head, which corresponds to extension in vertex presentation. The inferior surface of the lower jaw rests on the margins of the descending rami of the pubes; restitution of the face thus occurs, followed by external rotation as in vertex births. On the other hand where the chin is directed posteriorly, the birth of the child is impossible in ordinary pelves, since this would necessitate the passage of a fetal diameter larger than any of those afforded by the mother's pelvis. Anterior rotation of the chin may occur internally and permit of a satisfactory termination of the delivery.

The diagnosis of face presentations should be made as early as possible before engagement has been attempted or advanced. Through the abdomen the head can usually be felt above the brim and to one side; this prominence being on the same side with the fetal back. Palpation of the latter is interfered with owing to the extension of the head which is present, and a sulcus can frequently be felt between the head and the back. Vaginal examination discloses the presenting face filling the pelvis as with ordinary vertex presentations. Moreover, the ridges over the eyes, nasal bones, malar and alveolar processes, and the chin can usually be palpated if the cervix is dilated. The prognosis for both mother and child is less favorable than with vertex presentations but more favorable where the chin points anteriorly than where it points posteriorly. The difficulties in the labor arise chiefly from the prolapse of the cord or the small parts because of the disproportion between the face and the pelvic brim. As greater uterine force is necessary for delivery failure of the pains is frequently met with. It has been estimated that the maternal mortality is four per cent. and that of the children from eight to ten per cent. The disfiguration of the child's face which is usually present soon disappears but the swollen lips may interfere with nursing. Exhaustion and necrosis of the soft parts from undue pressure are the principal dangers to the mother. The treatment of the case depends on the time when it is first seen. Where no marked disproportion of the head and pelvis is present, delivery in most cases where the chin is anterior is possible by the natural resources. If the case is seen, however, before the face has engaged and when the head can still be pushed back from the brim it is advisable to correct the malposition by flexing the head on the chest and holding the same there until the pains have firmly engaged the head in its new position. It will be found, however, that in many of these cases flexion cannot be maintained as the paralysis of the flexor group of cervical muscles permits those on the posterior aspect of the neck to contract and thus keep the head extended. In face cases where a cesarean section has been done for this or other causes and where no engagement of the face had resulted, an extended position of the head in the child remained for a week or more after labor, showing the futility of attempted flexion in such instances. If the face is well engaged and the labor progressing it may be safely left to Nature, rotation being favored, however, by keeping the patient on the side to which the face points. Should uterine inertia supervene, delivery by forceps may be required. If a mentoanterior face case is converted into a vertex presentation an occipitoposterior position will result so that the latter also requires correction. If the head is very large pubiotomy or cesarean section may be necessary, and if the cord or an arm is prolapsed podalic version is generally demanded. In the latter case care should be taken to ascertain whether any disproportion between the fetal head and the maternal pelvis is present. If the chin in a face case points posteriorly and firm engage-

ment has not taken place, conversion into a vertex presentation is necessary as described above. If this is impossible, rotation into a mentoanterior position may suffice, although anesthesia is usually necessary with the latter procedure. In the presence of a large head or prolapse of the cord or fetal small parts, the same course must be followed as in mentoanterior positions. Where the face is firmly engaged in the cavity of the pelvis and tonic contractions of the uterus are present, delivery may be favored in promoting extension by drawing the chin downward and forward during the pains. The forceps application in this condition is fraught with great danger to both mother and child and should not be attempted except by those particularly skilled. In impacted face cases delivery by pubiotomy is indicated where the child is alive, or a craniotomy must be done if the fetus is dead. Of the numerous methods for converting a face into a vertex presentation, the most satisfactory is that of Thorn by which under complete anesthesia the head is flexed on the chest and the lordosis is converted into a kyphosis. It is necessary to introduce the hand which corresponds to the back of the child, into the uterus lifting the face out of the pelvis and then making backward pressure upon the chest. As this is being done the breech is carried in the direction of the feet upward.

Brow presentation may be regarded as an attitude between vertex and face, due to a partial extension of the head. The condition is uncommon and usually undergoes spontaneous conversion into either a vertex or a face presentation. The positions are similar to those of face presentations and the causes likewise. The occipitomental diameter of the head engages with the transverse at the pelvic brim as a result of which the brow descends into the cavity and becomes arrested. This complication has been estimated to occur about once in 2,000 labors. The abdominal signs are usually indefinite and the diagnosis must be made by vaginal examination. It is only when sufficient dilatation has occurred to permit palpation of the orbital ridges that a brow presentation can be recognized. Where the membranes have ruptured and a caput is present, the diagnosis is particularly difficult and where a doubt exists, an examination should be made under an anesthetic. When the brow presentation persists delivery is impossible except in the presence of a small child and a large pelvis. The maternal mortality is about ten per cent. and the fetal thirty-three per cent. The treatment consists of a conversion into a vertex or face where no indication exists for rapid delivery. In the latter emergency complete internal version is required, or if the brow is irreducible, pubiotomy may be necessary when the child is alive, or craniotomy if dead. There is no normal mechanism for the delivery of this complication.

Breech presentations include three forms; those in which the buttocks present (frank breech) and those in which the knee or foot presents. These distinctions are necessary only as applied to the treatment of the individual case and have little importance as regards the mechanism. Breech presentations occur about once in sixty cases and the causes are pelvic deformities, tumors of the uterus, placenta previa, twins, hydrocephalus, prematurity, relaxed uterine wall, hydramnios, and a small fetus. Depending on the position of the sacrum we may distinguish four positions, the left and right sacroanterior and the right and left sacroposterior. The mechanism in a frank breech is as follows: The breech descends into the pelvis and as the posterior hip impinges on the pelvic floor it is shunted downward, inward and backward until it appears at the vulvar outlet while the anterior hip rotates under the pubic arch where it is checked and the posterior hip delivered first. After the delivery of the trunk the shoulders rotate and likewise the head. In a dorsoposterior position the occiput as a rule comes eventually to the front and as the nape of the neck is caught under the pubic arch the head is expelled by a movement of flexion around this as a pivot; the face, forehead, and vertex being in turn swept over the perineum. In persistent dorsoposterior positions the head is delivered after the trunk by being rotated around the posterior edge of the vulvar orifice, the chin catching under the pelvic brim.

The diagnosis of breech presentation is made by finding the dorsal plane on the right or left side of the abdomen with the head usually above the umbilicus. One of the shoulders and the fetal heart are also found above the latter point. The presenting part is irregular in shape and not so hard as the head. Vaginal examination discloses the absence of the hard mass of the vertex with its fontanelles and sutures, and the tuberosities, the tip of the coccyx, the anus, and genitals are usually felt. If the foot or knee presents this is readily identified but in differentiating between breech and vertex a complete exploration of every accessible part should be made. The prognosis for the mother is good except that lacerations of the cervix and perineum are most apt to occur. The first stage of labor is usually tedious and the second stage often more rapid. The fetal mortality where delivery is natural is about ten per cent. especially in primiparæ. The chief cause of death is asphyxia from interference with the blood supply due to retraction of the uterus after the birth of the trunk and from compression of the umbilical cord during and after engagement of the head. Fractures of the fetal arms or legs or the clavicle are likewise apt to result during the manipulations of delivery.

In treating breech cases external version may be attempted before labor but is usually unsuccessful. As the chief danger to the child arises from the difficulty of delivering the aftercoming head, it is essential that ample dilatation of the cervix, vagina, and vulvar outlet be secured. If the arms can be kept flexed so that by extension they will not increase the diameter, the delivery of the head will be much facilitated. The direction is frequently given to flex the head by pressure directed through the abdomen but as this requires skilled assistance and is often rendered impossible by a rigid or fat abdominal wall, the procedure had best not be relied upon in breech delivery. It is advisable to determine the position of the arms in every case as soon as the tip of the scapula is born and if on exploration the arms are found extended, they can be delivered much more readily at this time by sweeping them over the face of the child and thus assuring oneself that they will not complicate the delivery of the head. Even in cases where the arms have been delivered, the head may be firmly impacted in the brim and considerable traction will be necessary to dislodge the same. This can be largely aided by pressure directed against the head above the brim, care being taken of course that the bladder is empty. In the presence of slight contractions of the pelvis, the inlet diameters can be somewhat enlarged by placing the patient in the Walcher position. It may be necessary to apply forceps to the sides of the aftercoming head in order to affect its delivery. When the face is at or near the outlet the insertion of one or two fingers in the child's mouth while the body is supported on the forearm of the operator will aid considerably in the delivery, but care should be exercised not to use extreme force in this procedure. If the case is seen before the breech has engaged firmly in the pelvis, the delivery of one or both legs will be found of great assistance. The anterior one had best be delivered first and will serve as a tractor in case the expulsive force is diminished. In every case of breech delivery a warm towel or blanket should be at hand to wrap up the baby as soon as the trunk is born so as to prevent premature efforts at respiration. The pulsations in the cord should be carefully watched and as much as possible

of this structure pulled down so as to avoid compression and traction on the same. As already stated extraction of the arms had best be done in every case but if these have become extended the posterior arm should be brought down while the trunk is drawn downward in the pelvic axis and carried to the side opposite the occiput. The free hand is then carried up along the child's back and one or two fingers slipped over the shoulders and along the humerus to the elbow. The finger is inserted in the bend of the latter and the arm swept in a circular direction across the face and then extended. In delivering the second or anterior arm the child's body is swung to the opposite side and the other hand introduced, the bend of the elbow is seized and the arm then swept over the face. If the arm has been caught back of the head it may be necessary to turn the body completely around in the direction of the engaged arm.

In cases where the breech is impacted and the arms extended it may be impossible to deliver a foot and then traction must be resorted to by hooking the finger in the groin or using for this purpose a fillet. The latter consists of a strip of muslin or gauze which is sterilized, greased, and knotted at one end. The knotted end is pushed over the groin and brought down on the opposite side of the thigh. In some cases this fillet may be used to encircle the pelvis. Where the fingers or the fillet fail, forceps may be applied to the breech, one blade being placed over the sacrum and ilium and the other over the posterior surface of the opposite thigh. An application over the trochanter, especially in dorsoposterior positions, may be employed but the forceps must only be used to bring the breech within reach of the finger or the fillet.

In a *transverse presentation* the long axis of the fetal body lies along the direction of the transverse diameter of the pelvic inlet. In many cases natural conversion results and in others the shoulder or the arm becomes the presenting part after labor begins. The causes of transverse presentation are usually mobility of the fetus, flabby uterus and pendulous abdomen, multiple pregnancy, fetal tumors, fibroids in the lower uterine segment, pelvic deformity, and low placental attachment. Four positions are recognized, right and left scapuloanterior and right and left scapuloposterior, according to the direction of the presenting scapula.

Transverse presentations may be recognized by the fact that the abdomen is unusually wide while the fundus does not rise above the umbilicus. After labor is established both fetal poles are absent from the brim. The head can usually be felt in one or the other iliac fossa with the breech on the other side. Vaginally the most significant fact is the absence of any presenting part at the onset of labor. The prognosis for the mother is bad in persistent transverse presentation and likewise for the child, although premature or macerated children may be born spontaneously. Pressure necrosis, exhaustion, or spontaneous rupture of the uterus may result to the mother and the child suffers from the prolonged labor, a possibly prolapsed cord, and the operative delivery. Spontaneous delivery may occur as the result of version or evolution. In the former the shoulder is converted into a breech or a vertex by the uterine contractions. It is favored by having the patient assume the squatting posture, the thigh of the side toward which the breech points being forcibly flexed on the abdomen. As the result of spontaneous evolution the fetal head as the child is driven down slips over the symphysis and the anterior shoulder becomes fixed under the pubic arch. The opposite shoulder is then forced down over the posterior wall of the pelvis and is expelled first, followed by the trunk. This process is possible only with a small child or a large pelvis. Expulsion may occur with the trunk doubled on itself in a dead and macerated child or when the pelvis is very large.

If seen before labor and the pelvis is normal externally, cephalic version may be resorted to and the child retained in position by means of a properly applied binder with lateral compresses. If the patient is in labor, rupture of the membranes must be avoided and after noting the relations of the child and the capacity of the pelvis the cervix may be dilated and version performed, preferably complete podalic followed by extraction. If the membranes have ruptured the treatment is determined by the amount of cervical dilatation, condition of the uterine wall, as well as that of the patient and fetus. If possible the cervix should be dilated and version done or if prolapse of the cord is present, incision of the cervix may be required for delivery. When the fetus is impacted and irreducible, decapitation may be necessary. Cesarean section should also be considered when the child is alive and labor has not been prolonged.

The following writers among others have been consulted in the preparation of the foregoing article: J. W. Williams, H. Sellheim, A. Dührssen, J. O. Polak, J. B. De Lee. GEORGE W. KOSMAK.

La Bourboule.—La Bourboule is situated in the central portion of France, directly south from Paris, from which it is distant 282 miles, about ten hours' ride by rail. It is famous for its hot *arsenical* springs. La Bourboule lies in a valley of the Auvergne Mountains, at an elevation of 2,700 feet. It is open to the east and south, but protected on the north and west by the mountains. The climate possesses the characteristics of that of medium altitudes; it is tonic, sunny, and invigorating. Thunder-storms of short duration are frequent, as in other mountain resorts. The scenery is varied and attractive, and there are many interesting excursions in the neighborhood. The season extends from May 25 to October 30.

The fame of these waters depends upon the arsenic they contain, being the richest alkaline hot arsenical waters known. They also contain in very considerable amounts bicarbonate and chloride of sodium. They are employed in diseases for which arsenic is applicable and beneficial. There are also cold springs, but the hot ones are chiefly if not exclusively employed.

The two hot springs are "La Source Choussy-Perrière," of a temperature of 136° F., containing in a liter three grams of sodium chloride, 3.8 of sodium bicarbonate, and 0.028 of sodium arsenate, or nearly half a grain per liter, equivalent to about twenty drops of Fowler's solution; and "La Source Croizat," of a temperature of 113° F., containing 5.63 grams of sodium chloride, 3.0 of sodium bicarbonate, and 0.025 of sodium arsenate. The water is clear, with a salt taste and without odor. It is used for drinking, baths, and inhalation; the internal use of the water is the most important, and it is drunk at about a temperature of 100° F. in daily doses of from three to eighteen ounces, or even more, divided into three portions, taken at different times of the day.

The baths are taken separately or in a common pool, and in skin affections they are often prolonged for several hours, but the water is not very hot. In the inhalation chambers the water is finely pulverized, and thus employed in respiratory affections. Pulverization chambers with numerous apparatus for nasopharyngeal and cutaneous affections, and various kinds of douches, vapor baths, arrangements for dry and wet massage, are all found in the well-equipped bath establishment.

The diseases for which these waters are applicable and beneficial are: first, chronic skin diseases, such as eczema, ichthyosis, psoriasis, lichen ruber, lupus, urticaria, etc.; second, chronic diseases of children, such as glandular enlargements, scrofula, tuberculous diseases of the bones—weakly children and those with a tuberculous inheritance, and, as well, those with whom the

seaside disagrees, are also benefited by these waters and the climate; third, anemia and chlorosis, when not amenable to the iron treatment; fourth, chronic catarrhal conditions of the pharynx, larynx, trachea, and bronchi, when there is an arthritic or neuroarthritic tendency, especially when associated with a skin affection; fifth, malarial cachexia, neurasthenia with anemia, certain cases of arthritis deformans, neuralgia resulting from malaria, the cachexia of syphilis, feeble, rheumatic, and gouty persons; sixth, diabetes and some forms of albuminuria.

Contraindications: Those conditions for which the water-cure treatment in general is contraindicated—advanced arteriosclerosis, degeneration of the myocardium, degenerative changes in the cerebral arteries, non-compensated valvular diseases of the heart, malignant diseases, extreme age, fever, and, in particular, a hemorrhagic tendency, cirrhosis of the liver, and renal lithiasis.

The duration of the "cure" is generally very short, varying according to the malady and the results obtained.

The accommodations are abundant and good. Four thousand persons, it is said, can be received at one time, and, as has been said, the bath establishments are well equipped and elaborate. There are the usual amusements found at French watering-places—music, theater, casino, parks, and promenades. Here, as at all well-known spas, reliable medical advice can be obtained.

The Bourboule waters are exported and can be obtained in any country. EDWARD O. OTIS.

Laccase is he term applied to certain enzymes which have an oxidizing action. They belong to the group of oxidases and their action is quite specific. Thus, the laccase isolated from the juice of the lac-tree has an oxidizing action upon polyhydric phenols, such as hydroquinone, but it is without influence upon tyrosine. See *Enzymes*. F. P. U.

Lachapelle, Marie Louise.—Celebrated accoucheuse and authoress of a most valuable treatise on the obstetrical art. Born in Paris, January 1, 1769. Her mother, who had previously been simply a registered midwife at the Châtelet Hospital, was given the position of head midwife at the Hôtel-Dieu in 1775; and she performed the duties of this important office with so much talent and zeal that a pension was granted to her by the authorities. Thus her daughter, Marie Louise Dugès, living day after day, all through her early youth, in the midst of pregnant women and women in the actual pains of labor, came gradually and without any effort on her own part to acquire a vast amount of knowledge, both theoretical and practical, with regard to the art of midwifery. In 1792 Marie Dugès became the wife of Dr. Lachapelle, Surgeon in charge of the service at the Saint-Louis Hospital, but she continued to reside with her mother at Hôtel-Dieu. Upon the death of her husband, not long after their marriage, she devoted all her energies to the work of aiding her mother. She frequently acted as midwife, and from time to time she even took her place in instructing pupils. In appreciation of her merits and faithfulness the authorities gave her, in 1795, the position of adjunct to her mother.

The celebrated lying-in hospital, La Maternité, was organized about the year 1800, largely upon the plans advocated by Madame Lachapelle, who was made its directress and also the chief instructress. The famous Baudelocque was appointed Obstetrician-in-Chief and Professor of Midwifery. To these two celebrated personages is due in about equal measure the glory of this great institution. Madame Lachapelle died October 4, 1821.

During her long service at La Maternité Madame Lachapelle collected a very large number of cases which had come under her observation, and she afterward utilized this material as the basis of one of the most instructive treatises on midwifery that had been published since the appearance of Baudelocque's *L'Art des Accouchemens*, in 1781. This book bears the title: "Pratique des accouchemens, ou Mémoires et observations choisies sur les points les plus importans de l'art," published by Antoine Dugès, nephew of the author; three volumes, Paris, 1821–1825. A. H. B.

Lacrymal Diseases.—Lacrymal diseases form about two per cent. of ophthalmic cases and some of them are the bête noir of special practice. Those of the secreting portion are relatively rare while those of the drainage system are comparatively common.

DISEASES OF THE GLAND.—Dacryoadenitis or inflammation of the lacrymal glands is rare.

Acute non-suppurative dacryoadenitis is similar in type to parotitis and may be coincident with mumps.

FIG. 3616.—Acute Adenitis of the Lacrymal Gland (Arthur Vance).
(From "Injuries of the Eye," Chicago, The Cleveland Press.)

It is likewise the accompaniment of other infectious disease, as influenza and variola, and may be present in leukemia. It has been seen with traumatic dislocation of the gland.

Acute suppurative dacryoadenitis may result from direct infection from the conjunctival cul-de-sac, from infectious diseases, and from injury. Metastatic dacryoadenitis has been described in gonorrhea.

Symptoms.—The lid droops, and there are tenderness, redness, and swelling of the upper lid and conjunctiva, especially the outer extremity; on everting the lid the lower part of the gland is visible. There may be slight exophthalmus and vertical diplopia. The case looks like one of orbital cellulitis, but the

skin is movable over the mass. Hyperpyrexia and pain are present.

Treatment.—Iced compresses should be applied for the first few days, followed by hot compresses to

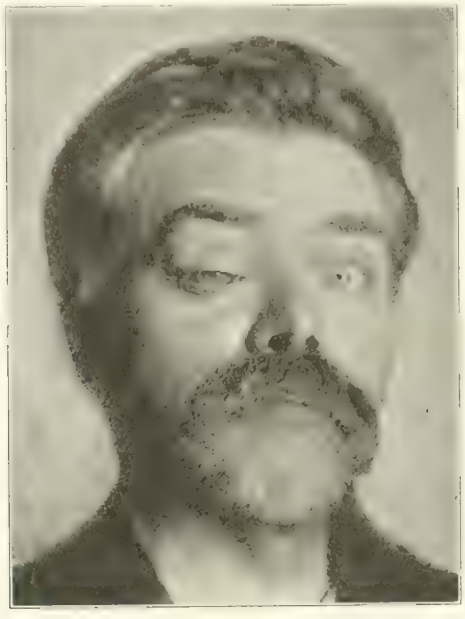

Fig. 3617.—Suppurative Inflammation of the Lacrymal Gland due to Penetrating Splinter of Wood (Author's case). (From "Injuries of the Eye," The Cleveland Press.)

Fig. 3618.—Bilateral Hypertrophy of both Lacrymal Glands (Case of W. T. Shoemaker).

relieve pain. Tincture of iodine, mercurial, or iodide of cadmium ointments are to be applied locally, with sodium salicylate or aspirin given internally. In suppurative cases, an opening should be made preferably through the conjunctival surface, a gauze drain being inserted. If the inflammation follows a punctate injury or the entrance of a foreign body, after removal of the latter, one should drain through an incision under the eyebrow.

Chronic non-suppurative dacryoadenitis may be the accompaniment of syphilis, tuberculosis, or the rheu-

Fig. 3619.—Dislocation of the Lacrymal Gland (Case of Edward Jackson).

matic diseases. The swollen, lobulated, tender mass at the outer and upper angle of the orbit must be differentiated from simple hypertrophy, adenoma, and malignant tumor. The use of iodine and mercurial ointment offers good results.

Chronic suppurative dacryoadenitis is due to infected wounds with more often retention of a foreign body,

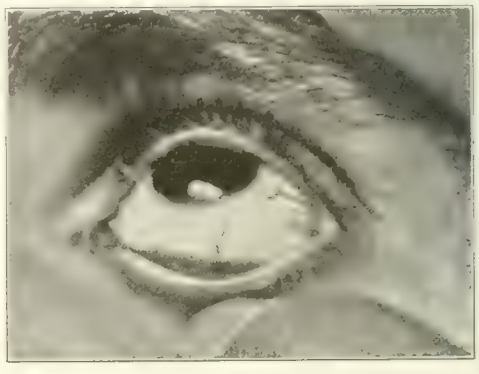

Fig. 3620.—Double Lacrymal Puncta (Case of Fred Tooke).

the removal of which, followed by drainage of the abscess, leads to recovery.

In *hypertrophy*, both sides may be enlarged. It is usually due to stoppage of the excreting ducts and caused by dacryoliths. In any unaccounted for case of hypertrophy, syphilis should be suspected and appropriate treatment instituted.

In hypertrophy the gland may be enucleated, but one should first search for dacryoliths and remove them, if present, by incision from the conjunctival surface.

Atrophy of the gland occurs with enophthalmos.

Fistula has been seen as a congenital defect, but usually results from trauma. It may be curetted or cauterized or the gland may be removed.

Traumatic dislocation is rare, usually due to prolapse through a wound in the upper lid. If seen early, the

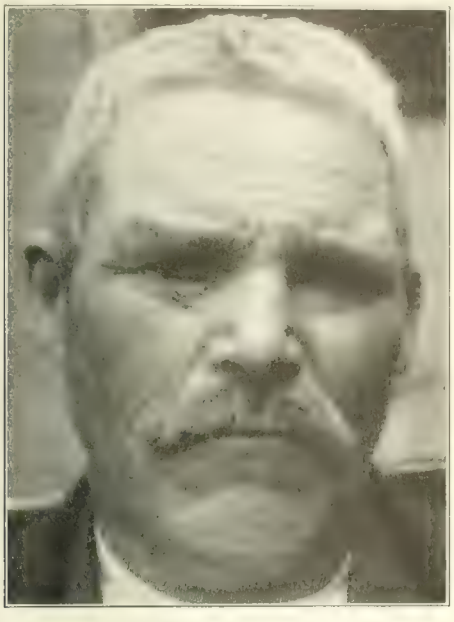

Fig. 3621.—Cicatricial Ectropion with Eversion of the Lower Punctum (Author's case). (From "Injuries of the Eye," Chicago, The Cleveland Press.)

gland may be returned to place and the wound sutured, but it is usually necessary to excise the prolapsed gland.

Tumors.—These are usually adenoma, but myxoma, fibroma, adenosarcoma, angioma, carcinoma, osteochondroma, lymphoma, cylindroma, and sarcoma have been reported. Hydatid cyst, dermoids, and tuberculosis occur. Chloroma, with clinical features

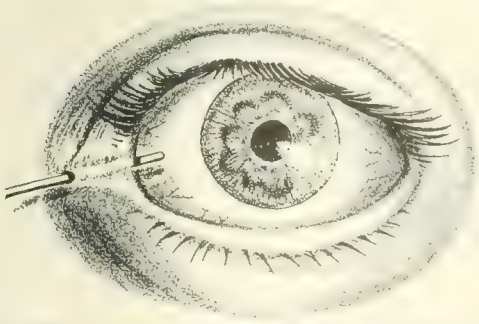

Fig. 3622.—Atresia of Lacrymal Canaliculi and Cicatricial Epicanthus due to Carbolic-acid Injury (Original drawing by Author from case).

similar to leukemia with bilateral enlargement of the lymph glands of the neck, is very malignant; it is confined to the early period of life; the other neoplasms occur in later life. Symmetrical enlargement of the lacrymal and salivary glands is known by the name of Mikulicz's disease. Surgical intervention removes the deformity and offers some hope of life even in malignant cases.

The Drainage Apparatus: Puncta and Canaliculi.

The common symptom is overflow of tears or epiphora.

Congenital anomalies of the puncta and canaliculi occur; in complete absence, the canals show only as furrows. They may be double or even quadruple.

Acquired Anomalies.—The slightest change in the natural relation of the lower punctum causes epi-

Fig. 3623.—Prelacrymal Abscess (Author's Case).

phora; this may be due to chronic conjunctivitis, ectropion, or facial paralysis. In the latter, Horner's muscle which causes compression of the duct, participates.

Styes, hordeoli, cicatricial contraction (causing ectropion) from injuries, evert the lid and displace the puncta and canaliculi; foreign bodies, especially cilia, stop the passage. Stenosis may result from chronic inflammation or injury.

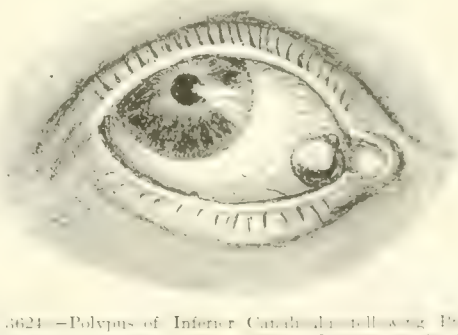

Fig. 3624.—Polypus of Inferior Canaliculus following Probing (Drawing by Author from case). (From "Injuries of the Eye," Chicago, The Cleveland Press.)

Treatment.—When the trouble is unaccompanied by lacrymal-sac disease, the cause in the conjunctiva or in the nose is to be treated. The puncta are to be dilated with the conical sound but the canaliculus should not be slit. Boric acid or zinc solution, colored by pyoktanin or fluorescin, may be injected by the Anel syringe.

Foreign bodies, such as hairs, cilia, pieces of barley

or wheat, should be searched for and if present, removed. In case of dacryoliths or leptothrix, the foreign bodies should be removed even at the expense of slight slitting of the canal.

Fig. 3625.—Acute Abscess of the Lacrymal Sac (Reproduced from Haab's Atlas).

Strictures of the canaliculus may be slit and dilated. Small polypi are occasionally found and should be pinched off by forceps.

The Lacrymal Sac and Nasal Duct.—*Dacryocystitis or inflammation of the sac and duct* may be acute or chronic, catarrhal or suppurative.

Etiology.—The vast majority of inflammations of the tear passages arise from catarrhal conditions or inflammations of the nasal passages, causing constriction of the tear ducts, which with the heat, moisture, and stagnation furnish favorable conditions for the development of germs, causing formation of mucus and pus. The most common pathogenic microorganisms are the pneumococci, streptococci, and staphylococci which are specially fatal to the cornea if abraded or wounded in the case of dacryocystoblenorrhea.

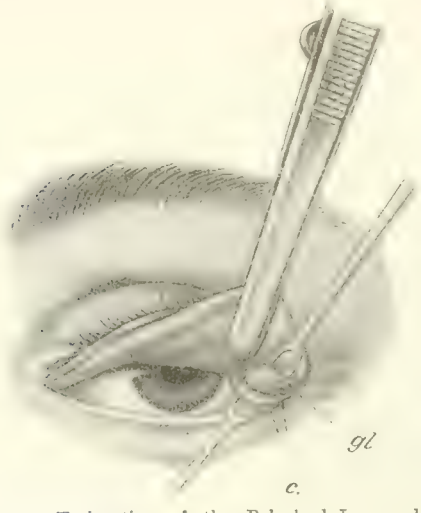

Fig. 3626.—Extirpation of the Palpebral Lacrymal Gland. Meller's "Ophthalmic Surgery," Philadelphia, P. Blakiston's Son & Co. The upper lid is turned upward twice, *i.e.* upon itself, and is maintained in this position by a lock pincette held by an assistant at the outer third of the lid. The conjunctiva (*c*) is freed on both sides of the gland. The wound is held open with double tenacula. In it is seen lying perfectly free the lower lacrymal gland (*gl*) appearing as a small nodule.

These germs do not specially affect the conjunctiva and even the blenorrheas of the latter or diphtheria do not affect the sac or canal. However, a veritable trachoma of the tear sac may exist.

Obstruction may be due to congenital defect from delayed absorption of the material existing in the sac and duct before birth; periostitis due to syphilis; struma and trauma from broken noses cause the balance of these cases of stillicidium and watery eye without inflammatory symptoms.

Acute Catarrhal Dacryocystitis.—The disease usually becomes chronic and mucopurulent before the patient consults the eye surgeon. The chief symptom is the epiphora although the conjunctiva is often hyperemic and the skin of the lower lid excoriated from the constant weeping.

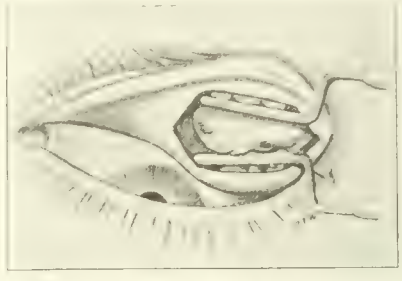

Fig. 3627.—Extirpation of the Tarsal Portion of the Laryngeal gland.

A chronic mucocele may be observed and pressure at the inner canthus over the sac causes a few drops of mucous discharge to appear.

Treatment.—First is that of the nose. One must secure good nasal respiration, ventilation, and drainage by reduction of the hypertrophic rhinitis by the galvanocautery, submucous resection of the turbinates or the septum, or submucous removal of septal spurs, followed by alkaline washes and sprays—especially camphor menthol adrenalin in oil. A search should also be made for the cause of the nasal catarrh in the regimen, general ventilation, constipation, etc.

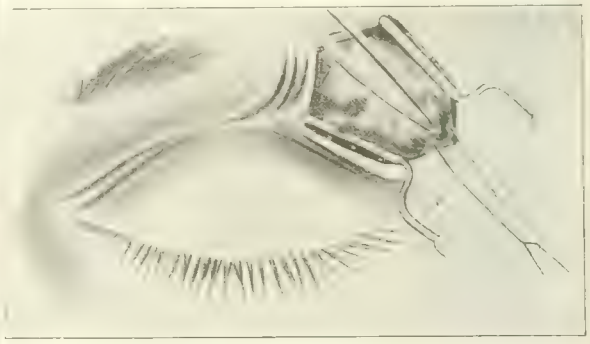

Fig. 3628.—Extirpation of the Orbital Lacrymal Gland. (Drawing by Author.)

Daily irrigation of the sac should be made with boric or zinc solution after dilatation of the canaliculi and injection of one per cent. cocaine solution with 1 : 10,000 adrenalin. The patient should press the contents out frequently and use a zinc collyrium. The silver preparations are advised in some textbooks but their use has lead to argyrosis and to permanent discoloration of the lids, and in some cases to malpractice suits, so they are inadvisable even if they occasionally cure. The canaliculus should not be cut, but probes may be passed for the stenosis.

The prognosis is favorable without operation on

the canaliculi or sac if the nasal condition can be improved.

Suppurative dacryocystitis follows incomplete recovery from acute attacks which cause stricture of the canal. The acute form or abscess of the lacrymal sac is associated with a chill and fever. A hard brawny swelling appears over the sac which closes the eyelids and is often mistaken for erysipelas and sometimes leads to it if the predominating germ be the streptococcus.

Fig. 3629. Ziegler's Double Conical Dilator.

If the abscess bursts through the skin an obstinate fistula may form.

Treatment.—Iced applications are to be made and followed in a few days by hot antiseptic compresses. An incision of the sac should be made through the skin and a gauze drain inserted, followed by excision of the sac upon subsidence of the swelling.

Canalicotomy and probing with antiseptic injections may be tried, but are painful, temporizing, and foredoomed to failure.

Chronic suppurative inflammation or dacryocysto-blennorrhea causes epiphora and obstinate conjunctivitis and is always a menace to safety of the cornea and vision.

Treatment consists at first in astringent and antiseptic injections and probing, upon failure of which resort must be had to excision of the sac.

Prelacrymal abscess consists of a swelling above the internal palpebral ligament and results in a fistula. It is usually due to trauma, but in very young children may be due to syphilis with caries of the lacrymal bone, or ethmoidal or frontal sinus disease.

The treatment is to open, curette, and drain the abscess.

Fistula of the sac is occasionally seen as a congenital anomaly but is usually caused by the rupture of a lacrymal abscess. It has been seen with caries of the upper canine teeth. The treatment is removal of the sac.

Obstruction and Stricture of the Lacrymonasal Duct.—The causes lie in nasal disease, extending upward, especially nasal infection and suppuration, sometimes following the exanthemata, and the constriction leads to dacrocystitis, or the cause may be from above due to impaction of foreign bodies as cilia, dacryoliths, or midway from exostosis due to fracture, cicatricial bands from healing of tuberculous or syphilitic ulcers. In a few cases, there is complete obliteration of the canal, the whole mucous lining being converted into a fibrous cord.

Predisposition toward lacrymal stenosis lies in the very flat or very narrow bridge of the nose.

Fig. 3630.—Weber's Canaliculus Knife.

The symptoms are mainly the watery eye, and mucocele or blennorrhea of the sac may coexist.

Diagnosis.—Compression of the sac with the finger will cause muco-pus to exude, and a colored solution injected by the syringe will appear in the nose if the canal be patulous. One should carefully use small probes after dilatation of the canaliculus.

Treatment.—We must treat the nose and treat the mucocele or the dacryocystitis. A certain proportion will need probing or the wearing of a style, the latter causing resorption of cicatricial bands by the constant pressure. The stricture may be cut with the Thomas knife, treated by electrolysis, or the sac may be excised. If the probing treatment is resolved upon, first small and then medium-sized probes should be used.

Lacrymal Operations.—Extirpation of the orbital portion of the lacrymal gland has been done in connection with excision of the sac in troublesome and

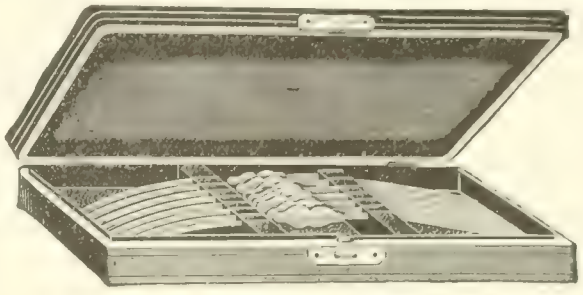

Fig. 3631.—L. Webster Fox's Lacrymal Sounds.

intractable epiphora, in dacryocystitis before opening the globe, when patients cannot take the time for or cannot stand the probing. I have not excised the orbital portion for these reasons, reserving the operation for great enlargement and tumor cases.

In operation for the excision of the orbital portion of the gland, the parts are cleaned, the eyebrow shaved and painted with tincture of iodine. A general anesthetic is given. A curved incision is begun about

Fig. 3632.—Charles Hermon Thomas' Stricturotome.

the middle of the eyebrow and extended four centimeters long, reaching to the outer canthus; the cut is made down to the bone, the wound is held open by retractors, the connective tissue is separated by the point of the scissors and the dissection is carried down to the capsule of the gland which is then brought forward by forceps and shelled out. The wound is sutured and dry gauze dressing applied.

The *palpebral* portion may be dissected under local anesthesia. Make strong eversion of the lid by rolling it up on lid forceps. Cut the conjunctiva open and shell out the gland.

Obliteration of the ducts by repeated cauterization may stop the secretion of tears.

Fig. 3633. Lacrymal Style.

Operations on the Drainage Apparatus.—The puncta lacrimalia may be opened and enlarged by the conical dilator. The lid is drawn outward, the point inserted in the punctum perpendicularly to the lid margin for one millimeter then turned horizontally and passed toward the canthus, as a preliminary step to syringing the sac or probing the lacrymonasal duct without slitting the canaliculus. A 0.5-per-cent. cocaine and 1 : 1000 adrenalin solution may be dropped into the inner angle of the eye before this procedure as well as before further dilatation by probing.

The *canaliculus* may be further dilated by the lacrymal probe without passing the instrument into the nasal duct, and this often relieves a troublesome epiphora.

Canalicotomy is occasionally necessary for removal of foreign bodies, growths and eversion of the puncture. When excision of the sac is refused or deferred, and when an abscess or fistula occurs, if probes are to be used, they must be of very large size—but these are

of doubtful value. One should use cocaine and adrenalin, dilate the puncta, stretch the lid, put in the probe-pointed knife of Weber or Stilling perpendicularly to the lid, pass it through the canalicular passage horizontally, with the cutting edge slightly toward the globe, and then raise the handle to the vertical, which action cuts the wall of the canal. After the operation 1 : 5000 bichloride of mercury ointment should be applied several times a day, and daily probing for a week keeps the passage open.

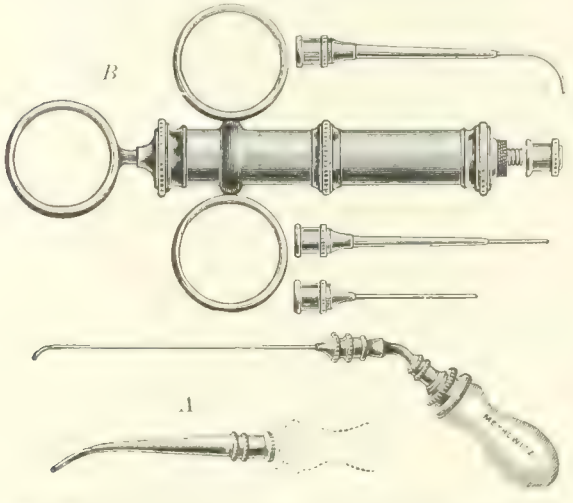

Fig. 3634.—Anel's (*A*) and Dunbar Roy's (*B*) Lacrymal Syringes.

Probing of the lacrymal passages and nasal duct is commonly used for stricture. It is a very painful procedure and requires great skill. As there is great danger of making a false passage, only olive-ended sounds, such as those of Fox, Snellen, or Caldwell should be used. While gradual dilatation up to very large sizes of probes such as those of Theobald is preferred by some and is claimed to be more or less successful in relieving epiphora, yet it is safer not to use larger than No. 5 or 6 Fox or Snellen.

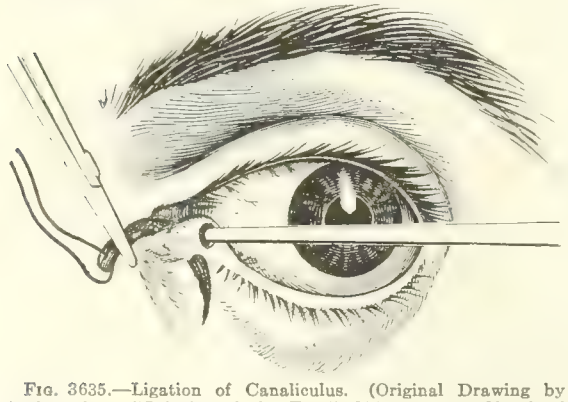

Fig. 3635.—Ligation of Canaliculus. (Original Drawing by Author; from "Injuries of the Eye," Chicago, The Cleveland Press.)

After cocaine and adrenalin and dilatation of the puncta by the conical sound, or slitting the canaliculus on a previous occasion, the lid is drawn downward and stretched outward, and the probe is inserted, first perpendicularly then pushed in horizontally until the bony wall is felt, then raised to a nearly vertical position and pushed slowly downward, being withdrawn a little if obstructions are felt and then pushed in again until it reaches the lining membrane of the floor of the nose. By using the head mirror and nasal speculum, the end of the sound may sometimes be seen under the inferior turbinate body. It may always be felt by passing a probe into the nose if properly done. One should use medium-sized probes and make several attempts (at different sittings) to pass all the way rather than use force. The sound is left in fifteen to thirty minutes and the operation is repeated every other day for several weeks and occasionally thereafter for years—even in the most successful cases.

A larger probe may be used by Caldwell's method, which saves the canaliculus. This consists in passing a small probe through the upper canaliculus, cutting down on it, and probing through the opening.

Strictures may be cut by the Stilling knife or Charles Hermon Thomas stricturotome, passed down as with the probe, the canal being incised in several places and the probing treatment used or a style inserted.

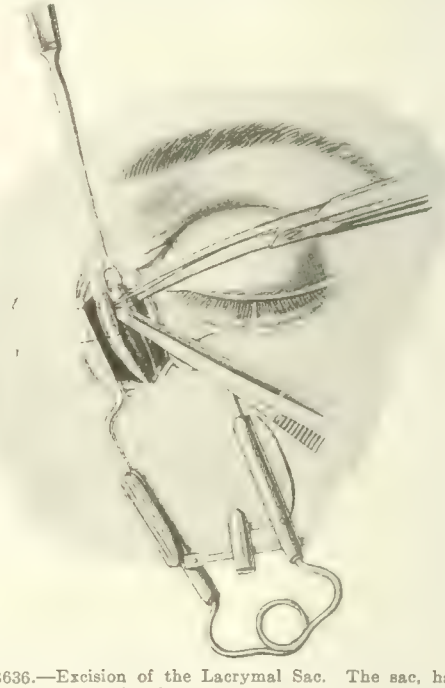

Fig. 3636.—Excision of the Lacrymal Sac. The sac, having been freed on both sides, is now for the first time grasped with forceps near its apex (*T*) and separated from the surrounding structures with sharp cuts of the scissors as near the sac wall as possible. The upper margin of the wound is lifted up with a double tenaculum or the Axenfeld retractor may be used. (From Meller's "Ophthalmic Surgery," Philadelphia, P. Blakiston's Son & Co.)

Styles of lead or other metal may be inserted and allowed to remain for weeks or months in patients who cannot attend the oculist regularly. Indeed, I am more partial to the style than to the painful procedure of probing.

Electrolytic treatment of stricture may be effected with the negative pole of two to four milliamperes of the continuous current every three to four days for two to three months, the probe being the negative, the positive pole being placed at the neck or held in the hand. This is a disagreeable and tedious and but occasionally curative treatment.

Syringing of the lacrymal passages and injection of astringent or antiseptic solutions is best made by the Anel or Roy syringe.

Obliteration of the canalicular canals by ligature or by cauterization may be a temporay operation made before opening the globe in the presence of mucocele or dacryocystitis but it is better to excise the sac.

Incision of the anterior wall of the tear sac in acute abscess is made by the Beer knife or scalpel plunged

directly into the sac, followed by a gauze drain and later by complete excision of the sac.

Excision of the lacrymal sac is the alternative operative for most of these cases. It is the most positively curative of all, and is the end resort in failure from treatment by other methods. It removes all possibility of danger to the cornea from purulent discharge, and contrary to what might be expected, actually has an influence in diminishing the flow of tears, but seldom rendering necessary excision of the lacrimal gland, the palpebral portion of which may be excised at the same time or subsequently.

The operation is tedious and difficult, calling for the greatest patience and skill upon the part of the operator. It is indicated for chronic dacryocystitis, mucocele, strictures, occlusion, fistula, in chronic inflammation, when the patient cannot or will not

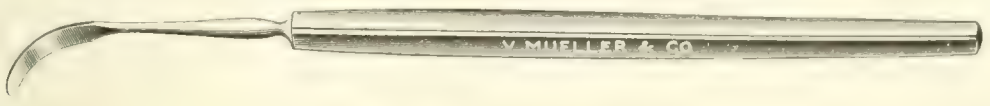

Fig. 3637.—Wilder Dissector.

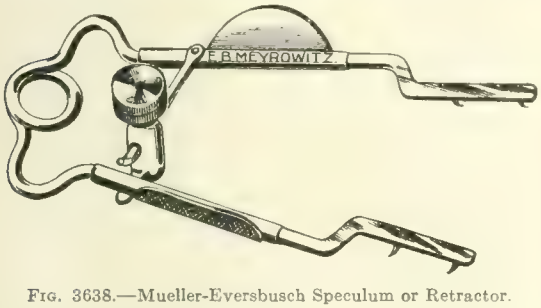

Fig. 3638.—Mueller-Eversbusch Speculum or Retractor.

submit to probing, and in cases in which an opening of the eyeball as for cataract extraction or iridectomy is to be made. It is a very satisfactory procedure and cures the disease permanently, which all or any of the others may not accomplish.

The sac, duct, and nose being previously irrigated, iodine is applied to the skin over the region of the sac, and the nasal cavity of the same side is plugged. A

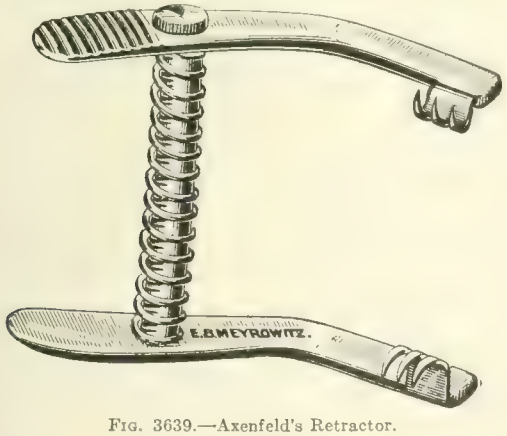

Fig. 3639.—Axenfeld's Retractor.

thick solution of starch colored blue by iodine may be injected to render the sac walls clearly visible. Local anesthesia is secured by hypodermic injection of four per cent. cocaine in 1:10,000 adrenalin solution. A Pravaz syringeful, one-third above the canthal ligament, one-third below, and one-third into the canal, renders the operation nearly bloodless and painless. I, however, prefer both ether and local anesthesia at the same time. Some operators obliterate the canaliculi by galvanocautery, but I have never found this necessary.

The curved incision begins just at the tendo oculi, and is carried downward and outward over the lacrimal crest which is the guide for the entire operation. It extends two centimeters downward and slightly outward, only through the skin, which is dissected out by the points of the scissors, and the Müller-Eversbusch speculum is then inserted. The superficial fascia and then the deep fascia are carefully dissected until the sac is reached which is carefully separated from its periosteal bed by the closed scissor points or the Wilder dissector.

The upper part is cut by the scissors, when hemorrhage results, which is controlled by forceps or adrenalin. The sac is then drawn out and cut away from the nasal canal by reaching downward with the scissors. A strabismus hook passed into the lower

Fig. 3640.—Anatomical Relations of Toti's Operation (Beard). 1, Insertion of tendo oculi; 2, Line of periosteal incision and limit of bone resection continued by dotted line; 3, entrance to nasal duct; 4, anterior lacrymal crest; 5, posterior lacrymal crest; 6, lacrymal bone. 7, part of lacrymal fossa, belonging to lacrymal bone; 8, part of fossa, belonging to superior maxilla. (From Beard's "Ophthalmic Surgery," Philadelphia, P. Blakiston's Son & Co.)

canaliculus aids orientation. The nasolacrymal canal is then thoroughly curetted with a fairly large curette. Care is taken to excise completely the sac or, if broken, to dissect out all the mucous membrane, for if any is left in the discharge will recur. One should watch carefully not to injure the cornea or let any of the purulent discharge come in contact with it.

The wound is closed with three sutures, iodine is applied, and a compress bandage of a roll of iodoform gauze, held in place by adhesive plaster, is applied. The dressing must be changed in forty-eight hours and the stitches removed on the fourth day. The result is union by first intention, immediate cure of the dis-

charge and usually of the watery eye. A later operation may be made on the palpebral portion of the lacrymal gland if the epiphora is still annoying.

Toti's Operation.—A general anesthetic is given. A crescentic incision of the skin is made, encircling the internal canthus, three to three and one-half centimeters long, three centimeters in front of the insertion of the orbicularis, down to the periosteum which is detached exclusively on the posterior ocular side. Tampons wet with adrenalin and cocaine solution are applied to the wound and nose. The bony edge of the orbit at the extension of the fossa sacci lacrimalis is resected, then an oval piece of bone bordered by the posterior crest, the inferior edge of the duct, and the elongation of the lacrimal crest above are removed. The nasal membrane must not be injured. The lacrimal sac is resected and then a piece of the nasal mucous membrane of a proper size is resected and applied to the external wall of the sac. The little finger or a cotton-wrapped probe should be inserted into the nose and the nasal membrane stretched. The membrane is now sutured and a tampon is applied so that the flaps come together, and then the skin is sutured. A pressure bandage is applied. The middle turbinate body may have to be removed. The sutures are removed on the fourth day.

Claims for better results by this method are made by various authors but the operation is more formidable and the ordinary resection of the sac gives excellent results. H. V. Würdemann.

Lactase.—The inverting enzyme capable of transforming lactose, or milk sugar, into dextrose and galactose is called lactase. It occurs in the intestinal mucosa especially in new-born infants and young mammals although its presence has been demonstrated elsewhere in nature as in yeast. See *Enzymes.*

F. P. U.

Lacteals.—See *Lymphatics.*

Lactic Acid.—Of the isomeric bodies known chemically by the generic name of *lactic acid*, the common acid, called technically *isolactic* acid, is the one used in medicine. This body is a product of a certain form of fermentation of sugar, a fermentation that occurs very readily in the case of milk. Hence the name and the common source of this acid. Lactic acid is official in the United States Pharmacopœia under the title *Acidum Lacticum*, Lactic Acid, and is required to be of a strength equal to seventy-five per cent. of absolute lactic acid ($CH_3.CHOH.COOH$). Lactic acid is a syrupy liquid, colorless and odorless, but sharply sour to the taste. It mixes freely with water, alcohol, and ether, is hygroscopic, and should be kept in well-stoppered bottles. The specific gravity of the official acid is about 1.206 at 25° C. (77° F.).

Although strongly acid, lactic acid is neither corrosive nor poisonous. It has been suggested as an adjuvant to pepsin in atonic dyspepsia; but it has been found to increase any existing tendency to hyperacidity. From theoretical considerations it was at one time expected to prove hypnotic, but it has not justified the expectation. Also it was vaunted as an antidiabetic medicine, but again has failed of success. The only really notable properties of the acid are that it dissolves to a considerable extent freshly precipitated calcium phosphate, and hence is useful in the preparation of the so-called *syrup of lactophosphate of calcium;* and that it dissolves false membranes, and so may be employed locally in diphtheria and croup. In the latter application the acid may be used by spraying or gargling, in admixture with water, of a strength of from four to twenty per cent. It is also used (in the form of twenty to fifty per cent. solution in glycerin) in cases of tuberculous ulceration of the throat. Of late, lactic acid has been credited with restraining the activities of the putrefactive germs in the intestines, and lactic acid bacteria and lactic acid drinks have alike been swallowed in the hope of attaining long life. Lactic acid may be administered internally in teaspoonful quantities or more, well diluted with sweetened water. The official dose is thirty minims (2 c.c.).

Edward Curtis.
R. J. E. Scott.

Lactophenin, lactyl para-phenetidin ($C_6H_4.OC_2H_5.NH.C_3H_5O_2$), is produced by the action of lactic acid on phenetidin in the presence of dehydrating agents. From phenacetin it differs only in the substitution of a lactyl group ($C_3H_5O_2$) for the acetyl group (CH_3CO). It occurs as a white crystalline powder without odor and with a bitterish taste, is split into its components by acids and alkalies, and is soluble in 300 parts of water (some authorities say 500 parts) at 15° C., in 55 parts of boiling water, and in 8.5 parts of alcohol. It is eliminated in the urine as paramido-phenol, which gives a deep red color with ferric chloride.

Physiologically, it does not differ essentially from phenacetin, except that its sedative and hypnotic tendency is greater. As an antipyretic, it reduces temperature rapidly and without much depression, though sweating may occur. Jaundice with sharp rise of temperature is said to follow the use of large doses of lactophenin; but the fever quickly subsides and the cases invariably recover. The dose is from five to fifteen grains (0.3 to 1.0 gram).

W. A. Bastedo.
R. J. E. Scott.

Lactose.—Milk Sugar. See *Saccharum Lactis.*

Lactosuria.—In the urine of pregnant women lactose may at times appear especially just previous to parturition. Lactosuria may also be observed in many instances in nurslings with diseases of the gastroenteric tract. Lactose in the urine may also be found when large quantities of lactose have been ingested, thus constituting a form of alimentary glycosuria. Of the various disaccharide sugars, lactose has the lowest assimilation limit. F. P. U.

Lactucarium.—"The concrete milk juice of *Lactuca virosa*; L. (fam. *Compositæ*)" (U. S. P.). Although thus defined, the product is actually obtained from several species of the genus. The one specified is native of Central and Southern Europe and is also cultivated for the sake of the lactucarium. It is a coarse, narcotic-smelling, and bitter-tasting biennial herb, with an upright, prickly, paniculately branching stem a meter or more in height, and long, spreading, ovate or oblong, sinuate dentate, pointed, and prickly leaves, and flowers similar to those of the common garden lettuce.

The herb itself has been official in the British Pharmacopœia, but is no longer so. *L. altissima* Bieb, of the Caucasus, is a gigantic species cultivated in France for the production of a French variety of lactucarium. *L. scariola* L., another prickly European species, is also said to yield a portion of the drug, as well as *L. sativa* Linn., the common salad or garden lettuce. The American species, *L. canadensis* L., has also been experimented with; it yields a lactucarium of but little bitterness and of inferior quality.

Lactucarium, in its present form, was introduced by Dr. Coxe, of Philadelphia, who collected it from garden lettuce at the end of the last century. Lettuce itself, as a medicine, is of much older date, and

garden lettuce, as a salad, has been cultivated for several hundred years.

Collection.—After the plants have sent up flowering stems, they are cut off about a foot from the top, when the "milk" flows out freely; this is wiped off with the finger and conveyed to a little cup, the operation being continued with successive stems until the cup is sufficiently filled. Fresh slices are cut off and fresh collections made daily, throughout the season. As first exuded, it is liquid and pure white, but it soon sets upon exposure, and turns yellow and then brown, upon the surface. When it has coagulated, it is emptied from the collecting vessel and dried by gentle heat. It is very apt to become mouldy. When this mould is only superficial, even though abundant, it may be rubbed off and the lactucarium used. Sometimes, especially when the masses are porous, the mould penetrates the substance and renders it unfit for use. The form of lactucarium varies with the details of its collection French samples are in small circular cakes, the English (Scotch) is in broken fragments and the German, which comprises most of that imported here, evidently consists of quarters of a plano-convex cake cut up before it is quite hard. It is, however, brittle, and often much broken.

Description.—Lactucarium is a brittle, structureless solid, of a gray or dull red-brown color, whitish or yellowish within, as shown by fresh fracture, of a wavy luster when freshly cut, heavy narcotic odor, and disagreeable bitter taste. It is a composite substance, and not wholly soluble in any one menstruum. Alcohol and ether dissolve portions of it; boiled with water, it forms a turbid mixture.

Composition.—The most abundant ingredient, constituting nearly half of it, is *lactucerin*, or *lactucon*, a wax-like substance, common to other milky juices. *Lactucin* is, however, its active principle. This crystallizes in pearly scales; is soluble in boiling water, cold alcohol, and acetic acid, but not in ether, and is very bitter. Yield, 0.3 per cent. *Lactucic acid* and *lactucopicrin* are other constituents. Besides these, lactucarium contains vegetable tissue, caoutchouc, gum, cellular tissue, and other vegetable substances, but no starch.

Action and Use.—Common lettuce is well known to be slightly soporific; its effects are occasionally quite marked. The various extracts of lettuce are also more or less so. These apparently contain a trace of hyoscyamine, but it is doubtful if this gets into the lactucarium. Lactucarium has so far shown itself to be an uncertain medicine, often of no value, but, when good, an efficient and pleasant hypnotic; its power of overcoming pain is slight when compared with opium —in fact, almost none—but simple discomfort or moderate distress is occasionally relieved by it. In cardiac asthma and restlessness it is frequently useful, and it may be tried in numerous cases in which opium is indicated but not well borne. It is free from the subsequent constipation and headache of opium.

Administration.—The uncertain quality of this drug makes its dose a tentative one, but gr. viij. ad xv. (0.5–1.0) should show some effect. It may be given in powder or pill, or the fifty-per-cent. official tincture. From the extract, a syrup (*Syrupus Lactucarii*, of ten-per-cent. strength of the tincture, five per cent. of lactucarium) is made; a useful vehicle and adjuvant for opium or other hypnotics.

H. H. Rusby.

Ladanum.—Labdanum. A resin collected in Greece and the Grecian Islands from several species of Rock Rose (*Cistus Creticus* Linn., *C. ladaniferus* Linn., *C. Cyprius* Lam., etc.; Fam. *Cistaceæ*), whose stems and branches abound in a sticky exudation. Two methods, both coarse and dirty, are in vogue for collecting it. The first is to whip or rake the bushes by an instrument having a number of leather thongs at the end, to which the resin sticks, and from which it is scraped off; the second, and more common, has been in use for many centuries, viz., to comb and press it out from the beards and wool of goats and sheep which pasture among it. It is then melted and manipulated, and often adulterated with other resins, or mixed with sand, etc., perhaps as much to give it solidity as for falsification. Common Ladanum is imported in snake- or worm-like coils; it is a dark gray or greenish-gray brittle solid, of resinous odor and a bitter balsamic taste. It consists of from twenty to eighty per cent. of *resin*, a small amount of *oil*, *gum*, and other vegetable products, and the rest of dirt, sand, or other foreign admixture.

Action and Use.—The same as those of other resins. As a medicine it is obsolete; plasters, fumigations, etc., sometimes contain it.

W. P. Bolles.

Laënnec, Réné Théophile Hyacinthe.—Born at Quimper, in Brittany, in 1781. He began the study of medicine at Nantes, under the guidance of his uncle, who was physician-in-chief of the hospitals of that city. In 1799 he entered the Paris School of Medicine, and received the degree of Doctor in 1802, after winning all the principal prizes in medicine and surgery. In the early years of his professional career

Fig. 3641.—Réné Théophile Hyacinthe Laennec.

in Paris Laënnec devoted a great deal of attention to pathological anatomy. At this period of their lives Dupuytren and Laënnec were eager rivals in their cultivation of this branch of medical knowledge; but it was not long before the latter branched off into an entirely different field of study. He cultivated a growing private practice in the heart of the city, and carried on, in the Necker Hospital, in which he was appointed an attending physician in 1806, original investigations into questions belonging to the domain of pathology. He also wrote numerous papers on the subjects in which he was specially interested. It was not until 1819, however, when he published his treatise on auscultation by means of the stethoscope that the medical world at large learned to appreciate how great a physician Laënnec really was. In 1822 he was called to fill the Chair of Medicine in the College of France; and in 1823, when the Faculty of Medicine was reorganized, Laënnec was given the clinical Professorship of Internal Medicine. He died of pulmonary tuberculosis at Kerlouanec, in Brittany, August 13, 1826.

The treatise on which Laënnec's reputation largely rests is entitled: "De l'auscultation médiate, ou Traité du diagnostic des maladies des poumons et du cœur, établi principalement à l'aide de ce nouveau moyen d'exploration," Paris, 1819; 3d edition, in three volumes, in 1831. A. H. B.

Lake Tahoe Springs.—Placer County, California.

Location.—These hot and cold mineral springs sometimes called Carnelian Springs, are located on Carnelian Bay, at the northern end of Lake Tahoe. They form part of the attractions of this famous inland sea. They are reached by rail to Truckee, and from thence by stage over a good mountain road in about two and one-half hour's drive. The scenery en route is grand. The Truckee River is crossed and recrossed mountainsides and heights are scaled, and fertile valleys, on which graze immense herds of cattle, are traversed. Forests of beautiful pine and cedar rear themselves at intervals, humming sawmills fill the air with life, and wild, romantic views greet the eye at every turn. Lake Tahoe is a noble sheet of water, having an altitude of 6,202 feet above the sea level. It is divided by the California and Nevada State line, has a length of twenty-one miles, a width of twelve miles, and is 1,645 feet in depth. The appointments at the springs resort are very complete. Excellent bathing facilities have been provided, where all kinds of cold or hot sulphur baths may be taken. The springs are about fifty in number, and are well kept and cared for. The waters are sulphurous and saline, and a few are carbonated. They contain sodium chloride, calcium sulphate, silica, organic matter, magnesium sulphate, and free sulphureted hydrogen gas. The baths are used with success in rheumatic and gouty troubles and the waters are taken internally for liver and kidney disorders, chronic constipation, and cutaneous diseases. The high altitude and invigorating mountain air recommend the location as a resort for bronchopulmonary affections. There are excellent facilities for camping, hunting, and fishing in the vicinity.

Emma E. Walker.

Lake View Hot Springs.—Lake County, Oregon.

Post-office.—Lake View. Hotels in the town.

Access.—Viâ Southern Pacific Railroad to Ager, California, and thence by stage. The springs are located one mile and a half south of Lake View, and four miles northeast of Goose Lake, one of the largest bodies of fresh water in the West (fifty miles in length, with an average breadth of fifteen miles). The elevation is about 5,000 feet above the sea level, and the surrounding country is of a mountainous character. The climatic conditions are very favorable. We are informed that the water has a temperature of 164° F., and flows at the rate of about 500 gallons per hour. A partial analysis by Dr. Parnell, postsurgeon at Camp Warner, Oregon, showed the presence of iron, soda, sulphur, magnesia, and other mineral ingredients. The water is said to be beneficial in numerous complaints, especially rheumatism. The attractions at this place afford excellent inducements for the establishment of a first-class health resort.

Emma E. Walker.

Lakewood.—The village of Lakewood, formerly known as Bricksburg, and situated in Brick Township, Ocean County, N. J., has attained a world-wide reputation as a winter resort for pleasure and health; and among the physicians of this country it is widely known as a place where the climatic conditions influence most favorably, during the winter and early spring seasons, those people who go there while convalescing from disease, whether acute or chronic.

Reference to the large geological map of New Jersey, accompanying the report of the State Geologist for the year 1881, shows that the village is situated forty-four miles south by west from New York City, nine miles back from the Atlantic coast-line on Squan Beach, and five miles back from the mainland shore of Barnegat Bay; and that it stands upon a tongue of sandy "pine-land" soil which runs back from the latter to a point some two and a half miles beyond Lakewood, has at Lakewood a breadth of a mile and a half, and is inserted, wedge-fashion, between two portions of an extensive "oak-land" district. Both the "pine-land" and the "oak-land" soils are sandy; the "pine-land" being especially so. The geological map just referred to shows us a very large extent of country, triangular in shape, which reaches from the Atlantic coast at Long Branch (twenty miles northeast of Lakewood) almost to the very shores of Delaware Bay, having an extreme length of about ninety miles and an extreme breadth of about forty-five miles. This area is made up exclusively of "oak-lands" and of "pine-lands," in the proportion of about two parts of the former to one part of the latter. The greater portion of the "pine-land" or "pine-barren" soil is to be found in the northern half of this great triangle; so that for this half the relative proportions of "oak-land" and of "pine-land" soils are exactly the reverse of those just stated—that is, the very sandy "pine-lands" are, throughout this northern half, twice as great in area as are the less sandy "oak-lands." It has already been stated that the village of Lakewood is built upon pure "pine-barren" soil, but the "oak-land" predominates over the "pine-land" in the immediately surrounding country. Nevertheless, by far the most extensive region of unbroken "pine-barren" country to be found in the State, comprising an area which may be roughly estimated at no less than 400 square miles, lies to the southward of Lakewood, and at a distance from the village of less than twenty miles; while the intervening "oak-land" region is intersected by tongues of "pine-land" similar to the one upon which Lakewood itself stands, but of decidedly greater area than this one. Other strips of "pine-land" country are dovetailed into the "oak-land" region to the northward. From this account of the geology of the New Jersey southern interior it must be evident to the reader that the soil, for many miles about Lakewood, is of an exceptionally sandy and dry nature.

Its distance back from the coast excludes Lakewood from the category of seaside stations; for, in Professor Smock's appendix to the "Report of the State Geologist of New Jersey" (1881), we read that "the influence of the ocean's waters is felt very decidedly to a distance of four to eight miles from the line of beach or outer coast-line, from Sandy Hook to Cape May," and that the climatic limit of the Atlantic coast belt in Monmouth County "is thought to be four or five miles; in Ocean County" (the county in which Lakewood is situated) "it follows closely the line of clearings or settlements, not going beyond the line of woods or into the forest belt. It is here from four to seven miles wide."*

Of the 3,234 square miles of forest area in the State of New Jersey, Ocean County contains 313,087 acres of forest land; to this and the prevalence of the pine in great abundance in this vicinity the salubrity of the place is greatly due. For decades past the balsam-laden air of pine-woods regions like Aiken, S. C., and Arcachon, France, has been looked upon by physicians as particularly beneficial for their convalescent patients, and Lakewood, which bears such a close resemblance to the former place, owes its reputation primarily to the beneficial influence of climate upon invalids of various types—not merely those with pulmonary complaints, but that far more numerous class of neurasthenics and convalescents from all acute diseases. In

* These two paragraphs are from Dr. Huntington Richards' article on Lakewood in the first edition of the Handbook.

localities where the pines grow, a sandy soil may always be looked for. Borings from the many artesian wells in the village proper show strata of almost pure sand down to a depth of 600 feet below the surface. Consequently the dryness of the soil and atmosphere is one of the most noticeable features of this region. Fogs are rarely seen, and the relative humidity is always low. Government meteorological records for Lakewood for a period of several years show:

	Average temperature.	Clear days.	Partly cloudy	Cloudy	Rainy days average
January	29.3	14.6	10.0	6.3	10.0
February	31.8	16.0	6.6	5.6	8.0
March	43.7	16.0	8.0	7.0	11.0
April	49.3	16.6	7.6	5.6	8.0
May	61.2	23.3	4.6	3.0	5.0
June	66.7	16.3	10.0	3.3	8.0
July	72.8	16.0	12.0	2.3	11.0
August	69.9	17.2	10.0	4.0	10.0
September	65.1	19.0	6.0	5.0	9.0
October	56.2	22.3	4.0	4.6	7.0
November	43.6	18.3	7.0	4.6	7.0
December	32.8	18.3	7.3	5.3	10.0

At Atlantic City the monthly average of clear days for twenty-nine years was 10.3, at Asbury Park 13.6, at Lakewood 17.8; of rainy days Atlantic City 10.3, Asbury Park 8.9, Lakewood 8.7. The number of clear days is thus shown to average per month seven more at Lakewood than at Atlantic City and four more than at Asbury Park. The actual thermometric readings for New York and Lakewood will be found to differ to only a slight extent, but the greater dryness of the atmosphere in the latter region conveys the impression that its temperature is noticeably higher than that of New York. At times there are very high winds, and, were it not for the protection afforded by the forests, walking and driving would on such occasions be unpleasant. Rains occur with about the same frequency as along this section of the New Jersey coast. During recent winters snow has covered the ground for only short periods of time; sleighing can rarely be enjoyed for one week's time, and occasionally an entire winter may pass without any sleighing. There is one peculiarity of the climate which deserves notice. I refer to the fact that a marked lowering of the temperature takes place at sunset and is associated with considerable dampness of the atmosphere. These conditions last for two or three hours; during the winter months, therefore, invalids should be within doors by sundown.

Originally intended for a health resort Lakewood has rapidly outgrown the dreams of its promoters and has developed into one of this country's most noted winter pleasure and residential resorts. Its population is now 5,500 and it is capable of caring for more than 2,500 transient guests in its hotels and numerous boarding-houses. Luxurious accommodations and an excellent cuisine are afforded by the leading hotels, while for those who prefer a quieter and less expensive mode of life there are many pleasant boarding-houses. The hotels and boarding-houses now decline to accept as guests those who are suffering from pulmonary tuberculosis. In one of the larger hotels there is a complete plant for hydrotherapy.

The season begins on October 1 of each year, and by the middle of November all the hotels are open and the cottages full. Daily morning and evening concerts are given at the hotels. The walks around the lake and into the woods are kept in the best condition possible; even after a heavy rain the soil absorbs the water so rapidly that in the course of a few hours it is possible to walk out without getting one's feet wet or muddy. Well-kept roads foster the spirit of outdoor life, and driving, bicycling, and automobiling are thereby made more enjoyable. Bridle paths add to the charms of the more vigorous horseback exercise, and cross-country riding may be watched at stated intervals each season. Polo games and tournaments prove the most attractive feature of the season and may be witnessed every spring and autumn on one of the finest polo fields in this country. A speedway, one mile and a quarter in length, brings many a gentleman with his trotting horses to the village. Then, besides, there are a country club, a golf club, and facilities for boating and canoeing on the lake, for bowling, and for lawn-tennis. There is an abundant water supply, chiefly from artesian wells, and the sewage disposal beds are constructed to care hygienically for the liquid and solid sewage of the community.

To the overworked business man; to the overtired nervous worn-out social devotee; to the parents who are seeking to place their children near to nature and give them a healthful out-of-door life and prevent them from being infected with disease; to those lovers of nature who delight in the warbling of birds and the quiet woodland scenes, the stillness of the forests and the wooded banks of the lakes and streams Lakewood offers rest and peace. Here are to be found well-regulated schools for boys and girls, churches of all denominations, and entertainment which is to be found in only a few resorts.

Lakewood is one hour and thirty-five minutes from New York City by rail, and two hours from Philadelphia.

IRWIN HOWELL HANCE.

Lamblia.—A genus of flagellate protozoans. The body is pear-shaped, the broad end having a hollow from the borders of which three pairs of flagella arise; the pointed end bears another pair of flagella.

L. intestinalis lives in the intestines of the mouse, rat, rabbit, cat, dog, sheep, and man. Infection is brought about by swallowing encysted forms; the adults are found in the large intestine. See *Protozoa*.

A. S. PEARSE

Laminaria.—The prepared stipes of *Laminaria digitata* Lam. (fam. *Fucaceæ*). This species is a large, foliaceous, olive seaweed, which from a branching and stout foot ("root") sends up a long, terete, strong stem, surmounted by a flat, leaf-like lanceolate, oval or more or less divided, and crispy-margined thallus. It attains a great size, often measuring six or eight meters long, with a blade one meter or more in breadth. Laminaria is not used in medicine, but its cylindrical, and, when dry, horn-like stipes were introduced as a substitute for the sponge tents, but are now seldom if ever used.

H. H. RUSBY.

Laminectomy is the operation of removing one or both laminæ of one or more vertebræ. The removal of one lamina is called sometimes hemilaminectomy. Laminectomy was first done by Macewen, and in recent years has been performed with increasing frequency, after spinal fracture, in cord and meningeal tumors, to remove foreign bodies, to divide nerve roots for the relief of spasticity in Little's disease, tabes dorsalis, etc. (Foerster's operation), and to drain collections of pus in the spinal canal, whether due to inflammation in the membranes or in the vertebræ themselves. The operation has been recommended also as a routine procedure in the paraplegia of Pott's disease, but its advisability here is very doubtful.

Laminectomy is not a simple operation, and he who would undertake it for the first time had best practise on the cadaver. The difficulties are great in the lumbar region, but less in the cervical and thoracic

regions where the wound is not so deep, and the laminæ are nearer the surface. General anesthesia is to be preferred. Various methods of operating have been recommended. The following, taken largely from Schmieden, commends itself:

The patient lies prone, with his body so propped up with cushions that the portion of the spine to be attacked is raised into prominence. Care must be used that respiration shall not be impeded. The surgeon may try the position himself, or the patient may arrange himself before he is anesthetized. Cushing's head-rest may be serviceable. The head should be rather low in order to lessen the sudden outflow of cerebrospinal fluid when the spinal membranes are opened. It is well to mark out a special vertebra before beginning, in order to prevent confusion. The incision may be slightly curved, or straight, and divides the skin and superficial fascia, bringing into view the tips of the spinous processes. The surgeon then divides the deep fascia on each side of the row of spinous processes, and with a broad chisel dissects off the muscles from the spinous processes, and from the laminæ on one side. This dissection is rough and is not done subperiosteally. Then the tissues are well retracted and the wound is packed tightly with compresses wrung out of hot salt solution, to check the hemorrhage, which is wont to be very free. Clamping all the small vessels takes much time and is not advisable. Any persistent bleeders, which the compresses fail to close, may be tied off. Next the tissues are dissected off from the other side of the spinous process and lamina, and all bleeding is stopped here also. Adrenalin may be found of use. The surgeon then divides the interspinous ligaments, and with a pair of sharp forceps "bites" off the spines one after the other. Next, with a hollow chisel, held very obliquely, he carefully removes a small piece of bone from the base of one spine, opening up the vertebral canal, and enlarges the opening as much as necessary with cutting bone forceps, working from within outward in order not to damage the spinal membranes. The laminæ are removed down to their base, and the hemorrhage from the bone may be checked by breaking up the marrow with a small dull-edged chisel, or with blunt hooks, thrust into the bone canals.

When all the laminectomies have been completed, all bone splinters, clots, etc., are removed very gently, and by blunt dissection the fat lying upon the dura is divided. All hemorrhage must be checked, and after the wound is packed, the skin is disinfected again, the bone instruments cleared away, and the surgeon's gloves changed. With the wound edges well retracted, the dura is seized with fine forceps, nicked with a knife very carefully, and then slit up, and retracted by fine silk inserted into its cut edges. The outflow of cerebrospinal fluid is sponged up gently.

From this point on the operation will vary according to the nature of the lesion for which it is done. When it is finished the dura must be "delicately" and exactly sewn up with catgut or silk. Then follow sutures in layers. Drainage is not advisable.

LEONARD W. ELY.

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La Motte, Guillaume Mauquest de. One of the most skilful accoucheurs of the seventeenth century and a very influential writer of that epoch. He was born at Valognes, in Normandy, June 27, 1655. He studied medicine at Paris, and devoted himself chiefly to surgery, his service in that branch at the Hôtel-Dieu covering a period of five years. He afterward settled in his native town, where, during half a century, he carried on a very large and most successful surgical and obstetrical practice. The experience which he gained in this field forms the basis of the valuable treatises which he has handed down to posterity. In the preface of his treatise on Labor he says: "For twenty-five years I observed with the greatest care and unceasingly; then I wrote down the facts which I had observed; and finally I formulated the reflections which I had made upon these facts. I look upon the recorded observations as something fixed and stable for all time, whereas my conclusions with regard to their significance are of a changeable nature. Indeed, in many instances I have, after further experience, based upon more accurately made observations, felt compelled to draw quite different conclusions." This treatise on labor was held in high esteem for many years, and Levret speaks of it as "worthy of being followed as a model." La Motte's treatise on surgery, says Sabatier, is quite remarkable in one respect: "it does not grow old; and, although many years have elapsed since it was written, its usefulness, its power to instruct, remains unimpaired." La Motte died at Valognes June 27, 1737. The two treatises referred to above bear the following titles: "Traité des accouchements naturels, non-naturels, et contre nature, expliqué dans un grand nombre d'observations et de réflexions sur l'art d' accoucher," Paris, 1715 (an illustrated edition was published in 1765 in two volumes); and "Traité complet de chirurgie, contenant des observations et des réflexions sur toutes les maladies chirugicales et sur la manière de les traiter," Paris, 1722, three volumes. The third edition of this work, which was published in 1771, was edited by the celebrated surgeon, Sabatier.

A. H. B.

Lanceraux, Étienne.—Born at Brécy, Brières, France, November 27, 1829. He studied medicine in Paris under Claude Bernard and Bazin, and received the degree of Doctor of Medicine in 1862. Not very long afterward he was chosen one of the Attending Physicians to the Hôpital de la Pitié and also to Hôtel-Dieu, both of which positions he held for many years. In 1872 he was appointed professeur agrégé. He died in 1910.

Of Lanceraux's many contributions to medical literature the following deserve special mention: "Des affections nerveuses syphilitiques" (in association with Léon Gros), 1861—awarded a prize by the Académie de Médecine; "Traité historique et pratique de la syphilis," 1866 (2d edition, with plates, in 1873)—awarded a Monthyon prize by the Académie des Sciences; and "Atlas d'anatomie pathologique," 1871—awarded a Monthyon prize by the Institut de France. A. H. B.

Lancisi, Joannes Maria.—Born at Rome, Italy, October 26, 1654. He began the study of medicine at an unusually early age, and devoted the larger part of his time to dissecting and to frequenting the hospitals. In 1672 he received the degree of Doctor of Medicine. In 1684 he was authorized to teach anatomy in the Sapienza College, and he held this position during the following thirteen years, to the entire satisfaction of the authorities as well as of the students. Malpighi was among those who took pleasure in following his instruction. When Lancisi was only thirty years old the Pope, Innocent XI., promoted him to be

a Privy Councilor and his physician-in-chief. When Pope Innocent XII. fell ill in 1699 he summoned Lancisi to see him in consultation, and the latter continued to prescribe for him up to the time of his death. Clement XI. honored Lancisi by making him a Privy Councilor and his physician-in-chief, both of which positions he held with great distinction for a period of twenty years. His death occurred January 21, 1720.

Haller, whose judgment in regard to the personal qualities and writings of the physicians of his time is fully to be trusted, speaks of Lancisi in the following terms: "As a pontifical physician he was esteemed most highly by Clement XI.; as a man he was very learned and at the same time philanthropic, loving to smooth over quarrels and to bring comfort to the dying." Of his published writings only a few may here be mentioned: "De noxiis paludum effluvies, eorumque remediis, libri duo," Rome, 1717. (Contains the history of five great epidemics which ravaged the Roman State.) "De motu cordis et aneurysmatibus, etc.," Rome, 1728, and Leyden, 1740; "Jo. Maria Lancisi opera quae hactenus prodierunt omnia, dissertationibus nonnullis adhuc dum ineditis locupletata," Geneva, 1717; and "Joann. Mariae Lancisi opera varia in unum congesta, etc.," Rome, 1745. A. H. B.

Landry's Paralysis.—See *Paralysis, Acute Ascending.*

Lane Mineral Springs.—Calaveras County, California. These springs lie thirty-five miles east of Stockton. They are 1,000 feet above the sea level, and are surrounded by hills and valleys clad in forests of pine. The main spring flows from fifty to seventy-five gallons per hour. The following probably incorrectly reported analysis is said to have been made by the San Francisco Refining and Analytical Association:

One United States Gallon Contains

Solids.	Grains.
Iron carbonate	122.00
Magnesium carbonate	38.51
Epsom carbonate (?)	29.76
Alumina	2.01
Sodium carbonate	8.52
Free sulphuric acid	15.24
Silica	15.20
Potassium carbonate	18.01
Organic matter	2.72
Total solids	251.97

Free sulphureted hydrogen gas, 105 cubic inches.

This water has been in use for several years, and is said to be beneficial in constipation, dyspepsia, chronic malarial poisoning, and in kidney and liver complaints.

Emma E. Walker.

Lanfranchi.—Born in Milan, Italy, in the thirteenth century. He took an active part in the dissensions between the Guelphs and the Ghibbelines, and for this reason he was driven out of Italy by Mathias Visconti. He settled in Paris, where medical science was at that time at a very low ebb. At the urgent request of Passavant, who was then the Dean of the Faculty of Medicine, he gave lectures on surgery, and these proved a great success. Partly through their influence and partly through that exerted by his writings, a decided revival took place in the art of surgery. According to the "Dictionnaire Historique de la Médecine," Lanfranchi may rightfully be considered the greatest surgeon of the Middle Ages up to the time of Guy de Chauliac. A. H. B.

Lange, Johannes.—Born at Lemberg, Germany, in 1485. After devoting himself for several years to literary and philosophical work he finally began the study of medicine in Italy, and was given the doctor's degree by the University of Pisa, in 1522. Soon after his return to his native country he was appointed chief physician to Prince Louis of Pfalz; and later he served several other princes, in succession, in the same capacity. During a period of several years he traveled over almost every part of Europe with Frederic II. His death occurred at Heidelberg, June 21, 1565.

The Dictionnaire Historique de la Medicine, from which the above facts have been gleaned, says that the collection of letters which Lange published, and of which the title is given below, furnishes one of the best sources of information with regard to the history of medicine during the sixteenth century. Several editions of this book were published between 1554 (at Basel, and 1689, but the one to be preferred is that which bears the title: "Epistolarum medicinalium volumen tripartitum denus recognitum et dimidia sua parte auctum," Hanover, 1605.

A. H. B.

v. Langenbeck, Bernhard Rudolph Konrad.—Born at Padingbüttel, Hanover, Germany, November 8, 1810. He was the nephew of the celebrated Konrad Johanna Martin Langenbeck. He studied medicine in Goettingen, and received his doctor's degree from the University of that city in 1835. Then he visited France and England for further purposes of medical study; and, upon his return to Goettingen in 1836, he began his teaching career as a "Privatdozent." In 1842 he was called to the University of Kiel to fill the regular chair of surgery and to be the Director of the Friedrichs-Hospital. In 1848 he acted as Surgeon-General of the Schleswig-Holstein Army in the war against Denmark; but, in the course of a few months, he was called to Berlin to fill the Chair of Surgery left vacant by the death of Dieffenbach (1847) and to assume the post of Director of the Clinical Institute for Surgery and Ophthalmology. After the campaign against Denmark in 1864 a patent of nobility was conferred upon von Langenbeck. He also played a prominent part in the wars of 1866 and 1870–1871. In 1882 he resigned his professorship; and upon this occasion the title of "Geheimer Rat" was bestowed upon him. From the date last named until he died (September 29, 1887) he made his home in Wiesbaden.

According to Pagel, von Langenbeck was, for a long time, universally admitted to be the leading surgeon of Germany. The new surgical procedures which he introduced and the improvements which he advocated in existing methods are too numerous to be mentioned in this brief sketch. A complete list will be found in Pagel's work. Langenbeck's personal characteristics are thus described by his German biographer: "Up to the very latest period of his long life he manifested a keen desire to learn, both by means of his own experience and also by the experience of others. He was an admirable teacher, and he possessed a very strict sense of duty. As a man he manifested a most lovable disposition, and his pupils always found in him a true friend and a wise councilor."

Of his published writings only a few of the more important ones may here be mentioned: "Die Subcutane Osteotomie," 1854; "Das permanente warme Wasserbad zur Behandlung grösserer Wunden, insbesondere der Amputationsstümpfe," 1855; "Die osteoplastische Resection des Oberkiefers," 1861; "Beiträge zur chirurgischen Pathologie der Venen," *Archiv für klinische Chirurgie*, I., 1860; "Ueber die Schussfracturen der Gelenke und ihre Behandlung," Berlin, 1868; and "Ueber die Endresultate der Gelenkresectionen im Kriege," *Archiv für klin. Chirurgie*, XVI., 1874. A. H. B.

Lannelongue, Odilon Marc.—Born at Castéra-Verduzan, France, December 4, 1841. He studied medicine in Paris under Denonvilliers and Nélaton, and received his doctor's degree in 1867. In 1884 he was chosen Professor of External Pathology. Of his published writings the following deserve to receive special mention: "De l'osteomyelite aiguë pendant la croissance," 1879; "Abcès froids et tuberculose osseuse," 1881; "Traité de la coxotuberculose," 1886; "Tuberculose vertébrale," 1888; and "Blessure et maladie de Gambetta," 1883. He died in the early part of 1912.

Lannelongue appears to have been one of the first to demonstrate the tuberculous nature of cold abscesses, fungous arthritis, and numberless cases of arthritis in infancy; and it is for this that his name will live in the future as that of one who has contributed to medical science a fact of great importance. At the time of his death he was President of the Academy of Medicine of Paris, and during the last fifteen years of his life he held weekly clinics at the Hôpital Trousseau. A. H. B.

Lanoform. See *Formaldehyde*.

Lanolin. See *Adeps Lanæ*.

Laparotomy.—See *Abdominal Section*.

de Lapeyronie, François.—One of the leading surgeons of the eighteenth century, justly celebrated for his devotion to his work and for the efficacious manner in which he advanced the art of surgery. He was born at Montpellier, France, January 15, 1678. After he had received a careful preparatory education he began the study of surgery at a very early age and was given the degree of Master of Surgery when he was but seventeen years old. Soon afterward he went to Paris and became one of Mareschal's private pupils. When he returned to Montpellier he began giving lessons in anatomy and surgery, and obtained a brilliant success as a teacher. He was also appointed at this time to the position of surgeon-major in the Hôtel-Dieu of that city. Not long afterward he attained considerable celebrity through his success in effecting a cure in a case which the other surgeons had pronounced incurable. The operation which he performed consisted in the removal of the entire frontal bone together with a portion of one of the parietal bones. In 1714 he was called to Paris to treat the Duke de Chaulnes who had sought in vain to obtain relief at the hands of the surgeons of that city. Here, again, he was entirely successful in effecting the desired cure; and, as a further result, the king expressed to him the wish that he would settle permanently in the capital. Under these circumstances, and especially as the Duke had purchased for him as a gift the exclusive privilege of doing whatever surgical work might be required in the jurisdiction of the provost, Lapeyronie complied with the wishes of his friends and took up his abode in Paris. Upon the death of Mareschal, in 1736, he was appointed his successor in the position of first surgeon to the king. But already before that event he had joined with Mareschal in inducing Louis XV. to appoint (in 1724) five new demonstrators in the schools of surgery, and also to found (in 1731) the Royal Academy of Surgery. Later, in 1743, he was successful in obtaining a decree to the effect that thereafter nobody should present himself as a candidate for the degree of Doctor of Surgery unless he had already secured that of Master of Arts. He died April 25, 1747, after a long and painful illness.

Of his published writings two of the most interesting are those which bear the following titles: "Mémoire contenant plusieurs observations sur les maladies du cerveau, par lesquelles on tâche de découvrir le véritable lieu du cerveau dans lequel l'âme exerce ses fonctions," Lyon, 1766; and "Observation sur une grande opération de chirurgie," in Mémories de l'Académie des Sciences de Montpellier, Tome I.

A. H. B.

Lappa. Burdock. "The root of *Arctium Lappa* L. and of some other species of *Arctium* (fam. *Compositæ*)," U. S. P. Burdock is a native of Europe, but is common everywhere as a garden weed. It is a rank-growing, bitter, disagreeable plant, from one to two meters (three to six feet) in height, with a stout, branching stem, and great, coarse, heart-shaped leaves. The flower heads are clustered along the stem and branches; they are rather small, and look like miniature thistles. The involucre is ovoid and green; its scales are numerous, imbricated in several rows, with spreading, sharp, stiff, inwardly hooked tips. The rose-purple flowers are tubular and perfect.

The root is the official portion, and should be gathered at the end of the first season, or the beginning of the second; it is biennial, fleshy, and usually simple, When dried, it is in gray-brown, wrinkled pieces, as thick as the thumb, and twenty or thirty centimeters long (eight to twelve inches), often split, to facilitate drying. The hairy bases of leaf stalks may remain attached to its upper end, or there may be a cottony or woolly tuft at the crown. Internally it is light brown, with a rather thick bark, a distinctly radiated wood zone, and a white, often broken pith or central cavity. Odor slight; taste mucilaginous and slowly bitter.

Burdock contains *inulin*, *mucilage*, nine per cent. of fat, a slight amount of amaroid, *lappin*, and a little tannin. Its inulin, which is in large amount, up to forty-five per cent., and its fat well adapt it to use as a food, and it is said that many cultivated varieties of it exist in Japan for this use. It is an old medicine, whose reputation depends upon pure empiricism. As an alterative and an antisyphilitic it is still occasionally used, but is more called for as an ingredient in proprietary medicines than in serious medication. Dose ʒss to ʒi (2.0 to 4.0). A fluid extract is official.

Burdock fruit, a small, black, curved, rough, seed-like akene, is much less used, but much more efficient. It contains a considerable amount of bitter glucoside and pungent resin. Its action appears worthy of investigation. The dose is gr. xv. to xxx. (1.0–2.0).

H. H. Rusby.

Larch Bark (N. F.).—The bark of the trunk and branches of the European Larch, *Larix europæa* D. C. (fam. *Coniferæ*), was formerly largely used for its rather mild terebinthinate and astringent properties, and was at one time official in the British Pharmacopœia. It has now almost disappeared from the Materia Medica, in favor of the more definite products of the same family.

It contains *volatile oil*, *resin*, a peculiar *tannin*, and *larixinic acid*. The turpentine and tannin make larch and other fir barks astringent and stimulating to the renal and bronchial mucous membranes. It is used to a slight and diminishing extent in bronchitis, vesical and urethral catarrh, as well as in purpura and other hemorrhages. A tincture (two and a half ounces to the pint) is an eligible form. Dose ♏ xv. ad xxx. (1.0–2.0) several times a day.

H. H. Rusby.

Lard. See *Adeps*.

Lardaceous Degeneration.—See *Amyloid*.

Larrey, Dominique Jean.—Surgeon-in-Chief of the French Army under Napoleon. The following

facts relating to his life are taken from Mary A. Clarke's admirable sketch of Baron Larrey in the *Trained Nurse and Hospital Review*, July, 1912. Born in 1766 in the south of France, at the foot of the Pyrenees. At the age of nineteen he was appointed Assistant Surgeon in the French Navy; at twenty-one he was made Chief Surgeon on one of the king's frigates which had been ordered to Newfoundland to protect the Frenchmen engaged in the cod fishery. After his return to France he entered the service of the Royal Hospital in Paris and treated those who were first wounded in the storming of the Bastile. When, a few years later, he entered the army he was struck with the inconveniences of the French ambulances and with the unsatisfactory manner in

Fig. 3642.—Dominique Jean Larrey.

which they were utilized for the benefit of the wounded on the battlefield. Believing that these vehicles might be improved he designed and submitted to General Custine, his commander, "a plan for *ambulances volantes*, or flying hospitals. These were very light carriages on springs, with either two or four wheels, and drawn by either two or four horses, the former for level countries and the latter for mountains. They were easy-running, furnished with mattresses, padded sides, and pockets for supplies, and the Hospital Corps could take them to the field while the battle was raging, and carry away the wounded as soon as they fell; they could also be used for transporting the dead." These new ambulances were brought into use for the first time in 1793 at the siege of Mainz, and they gave such satisfaction that they were afterward ordered for all the armies of the French Republic.

In 1797 Larrey, having been raised to the rank of Surgeon-in-Chief, accompanied Napoleon on his expedition into Italy. Both then and afterward, in the many army expeditions which he accompanied, Larrey showed himself to be the possessor of the very highest qualities—an admirable surgeon, thoroughly devoted to his military medical duties, and ready at all times to sacrifice his own comfort and even to risk his life if he might thereby relieve the sufferings or save the lives of the soldiers and officers entrusted to his care. "He was on the field in most of the bloody battles of Napoleon, but solely to relieve the suffering that followed in their wake. His one thought was for the wounded, whom he looked for under the heaviest fire and sometimes saved by marvelous heroism. Napoleon asserted that he was the best friend to the soldier he had ever known." In 1807 Larrey was given the honorary title of "Knight of the Iron Crown;" and in 1809, on the field of Wagram, he was created a baron of the Empire of France. He died at Lyons in 1842. A. H. B.

Laryngectomy.—*Definition.*—Laryngectomy is the name given to the operative removal of the larynx. It may be total or partial.

History.—The operation was first performed by Patrick Heron Watson, of Edinburgh, in 1866; next by Billroth, in 1873. Its technique has been developed by Solis-Cohen, Gluck, Durante, Brewer, Crile, and others.

Indications.—Laryngectomy is indicated in any operable case of intrinsic cancer of too great an extent to be dealt with by laryngofissure. It is also indicated in extrinsic cancer if there is little or no adenopathy, and not too great involvement of the upper end of the esophagus, as determined esophagoscopically.

Contraindications.—To do a laryngectomy in any case operable by laryngofissure is a calamity to the patient, because of the mutilated postoperative condition after laryngectomy, as compared to the practically normal larynx for breathing and speaking obtained after laryngofissure. The general contraindications are the same as for the latter.

Mortality and Results.—Of fourteen laryngectomies done by the author, two died within thirty days giving a fourteen per cent. operative mortality. Four died within a year of local recurrence, three lived one year and were thereafter lost to observation, two lived two years, dying of recurrence, one lived two and one-half years, dying of recurrence, one three years, dying of cerebral hemorrhage, one, seven years, dying of cancer of the stomach. Recapitulating this, of fourteen total laryngectomies, eight of the patients were free from recurrence at the end of one year, yet all are dead now and the average duration of life is but little over two years. Therefore it may be said that while the operative mortality is not large, the percentage of cures is very small. As stated by Delavan it is questionable if laryngectomy has added anything to the sum total of human life. In view of this, physicians should recognize the frequently malign nature of chronic hoarseness in order that cancer of the larynx may be discovered sufficiently early to permit of the really curative and relatively minor operation of laryngofissure. Vocal results after laryngectomy depend chiefly upon the development of a buccal voice, because in the modern operation the pharynx is completely shut off from the trachea, as suggested by Solis-Cohen, to prevent postoperative aspiration of pharyngeal secretions. The buccal voice produced by air taken in through the mouth becomes intelligible to those in contact with the patient; but it is lamentably inefficient as compared to the excellent voice after laryngofissure.

Operation.—*Preparation of the patient and position of the patient* are the same as indicated in the article on *Laryngofissure*.

Anesthesia.—Total laryngectomy may be done under local anesthesia by infiltrating first the skin and then the deeper tissues with normal salt solution containing one-tenth of one per cent. of cocaine. The operation, however, can be much more quickly done and the operative mortality can be diminished by using the intratracheal insufflation of ether, the catheter being inserted through the mouth by direct laryngoscopy and the patient being completely under before the operation is started. If the laryngeal involvement is sufficient to cause even a slight degree of stenosis of the larynx no attempt should be made to give a general anesthetic until the insufflation catheter is in place in the trachea. If insufflation anesthesia is not to be used, a tracheotomy must be done for administering the anesthetic, because the slightest degree of laryngeal obstruction will result in dangerous respiratory arrest, as soon as the patient begins to go under the influence of ether given by ordinary methods.

Technique.—Two classes of procedure are favored. In one, developed by Keen, the extirpation begins above at the thyrohyoid membrane, the larynx

being drawn forward as it is separated from the party wall, amputation of the larynx from the trachea being done when sufficient of these structures have been dissected loose and drawn out. During the dissection the anesthetic, which has been started through the mouth, is given through the outdrawn larynx. In the other method, the trachea is divided below the cricoid cartilage and the larynx is dissected away from the party-wall by working upward from below. Preliminary tracheotomy may be used with either method, and should be as low as possible. If done about a week beforehand preliminary tracheotomy has the advantage of anchoring the trachea firmly to the tissues of the neck by inflammatory adhesions, thus avoiding all tendency to retraction within the thorax when, later, at laryngectomy, the trachea is amputated and stitched to the skin. The inflammatory processes in the neighborhood of the trachea also close the various paths by which infection after laryngectomy might reach the mediastinum. This barrier may be increased by blunt dissection around the sides of the trachea at the preliminary tracheotomy.

The operation from below upward, which is preferred by most operators, including the author, is as

FIG. 3643.—Schematic Illustration of Laryngectomy with the Aid of Intratracheal Insufflation Anesthesia. The trachea and larynx are exposed during anesthesia administered with the Elsberg apparatus through the silk-woven catheter (*C*) held in place with the Janeway bite block (*D*). The incision has been made of T-shape, as will be understood by the sutured wound in Fig. 3646. The trachea is elevated forward by means of the grooved director inserted carefully between the trachea and the esophagus. Two anchor sutures are inserted around the first ring of the trachea, as shown at *A*, *B*, after preliminary incision of the interannular membrane.

follows: The front of the neck being sterilized with iodine in the usual way a T-shaped incision is made in the front of the neck (Fig. 3643), the vertical portion extending from the hyoid bone to a point as low in the neck as needed, but preferably not extending into the preliminary tracheotomy wound. At the upper end of the vertical incision a transverse one is made extending from one sternocleidomastoid ridge to the other. The trachea and larynx are laid bare. The trachea is carefully dissected loose from the esophagus at the lower portion of the wound and a grooved director is inserted between the esophagus and trachea taking care to avoid trauma to the esophagus. Two anchor sutures are put around the upper ring of the trachea as shown at *A*, *B*, Fig. 3643, and by means of these sutures, the trachea which is now divided is drawn forward and held by an assistant. A fresh sterile intratracheal insufflation catheter is inserted in the trachea for the continuance of the anesthesia. The larynx is then seized with forceps and drawn gently outward as it is dissected free from the esophagus (Fig. 3644). Great care is necessary not to make undue traction on the esophagus because of the shock thus produced, as shown by Boyce in collaboration with the author. The

FIG. 3644.—The trachea has been severed between the cricoid and the first ring, and has been drawn forward, and firmly fastened with the anchor sutures (*S*). A fresh insufflation catheter (*C*) has been inserted for the continuation of the anesthetic. The larynx has been dissected free from the esophageal wall (*E*). The larynx is held forward with the forceps (*F*).

vagi and the parathyroids should be carefully avoided, especially the latter. The removal of a part of one vagus, if necessary because of proximity to involvement, is usually without any ill effect. The dissection is continued upward and when the arytenoids are reached the pharyngeal mucosa is clipped free with scissors until the larynx is entirely liberated from all attachments (Fig. 3645). It is usual to clip

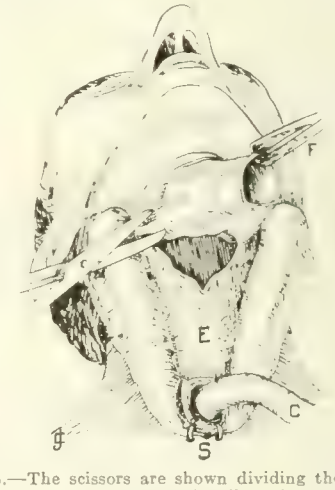

FIG. 3645.—The scissors are shown dividing the cornu of the thryoid cartilage. The pharyngeal wall has been divided so as to free the larynx posteriorly and this clipping will be continued around over the front so as to free the entire larynx.

off the cornua of the thyroid cartilage leaving them in the tissues with their attachments. As much as possible of the normal pharyngeal mucosa must be preserved for repair of the pharynx. All hemorrhage is carefully arrested at each stage of the operation; a clean, dry wound being essential for accurate work. The wall of the pharynx is now brought together and

sutured, the edges being inverted and the sutures not perforating the interior surface. Each layer of soft tissue is carefully stitched in place so as to afford the best support to the pharyngeal wall during deglutition. The cut end of the trachea is now drawn forward with the anchor sutures. The insufflation catheter is removed, and the trachea is stitched to the skin all around the circumference of its uppermost ring. The skin is accurately stitched (Fig. 3646) and a large gauze dressing wrung out of mercuric bichloride 1 : 10,000 is applied. In cases in which the

Fig. 3646.—The wound is stitched together throughout its entire extent after suturing the pharynx, putting in supporting sutures, and securely anchoring the trachea to the skin.

remaining pharyngeal wall is insufficient a dermal flap may be turned epidermal surface inward to fill the gap.

The most favorable time for the removal of involved glands is at the preliminary tracheotomy because this lessens the shock and the duration of the laryngectomy. Extensive dissection bulwarks the channels between the tissues by which infection might reach the mediastinum. If the glands are found involved all the way down to the upper thoracic aperture it means that the mediastinal lymphatics are involved and the laryngectomy is contraindicated. A tracheotomic cannula may be inserted for palliation and

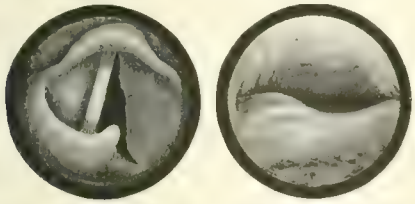

Fig. 3647.—At the Left is Shown the Condition of the Larynx Three Years after Hemilaryngectomy in a Man Aged 51 Years. The right-hand illustration shows the pharynx and mouth of the esophagus after laryngectomy for endothelioma in a man aged 68 years. (Author's cases.)

all hope of cure abandoned. Involvement of mediastinal glands can, in many cases, be determined by esophagoscopy and thus needless operation can be avoided.

After-care.—Antibechics, especially all opium derivatives, must be forbidden because blunting the cough reflex prevents the lungs ridding themselves of infective secretions. Feeding should be by a soft rubber catheter or very small stomach tube passed through the mouth. Plenty of fluid food must be given. Proximity of the tracheal opening soils the external dressings, which therefore must be renewed every two or three hours. A tracheal cannula is kept in the amputated end of the trachea until firm union has taken place, when, usually, it can be abandoned. A few strands of silkworm gut may be used for drainage at the lower angle of the wound but should be removed as early as possible. Should the pharyngeal wound break down the lower stitches of the external wound must be opened and free drainage afforded by fresh dressings inserted every half hour. At each dressing the drinking of a glass of sterile water will flush the wound by escaping. The patient should be propped up in bed on the second day and should be gotten out into a chair on the fourth day. The feeding tube can usually be abandoned and the patient can be permitted to swallow liquid foods in small sips at the end of a week or ten days.

Complications.—In the pre-aseptic days fatal septic complications were common. Notwithstanding the impossibility of preventing infection of the wound from pharyngeal secretions, modern aseptic surgery, with frequent dressings, as urged by the author, has

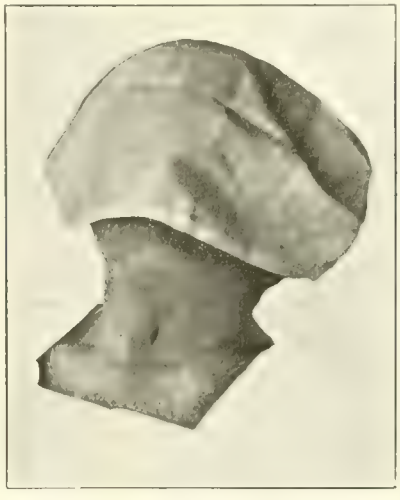

Fig. 3648.—From a Photograph of a Man of 68 Years, taken Nine Months after Laryngectomy for Endothelioma of the Larynx. The trachea was stitched to the skin and the pharynx closed. (Author's case. For interior view of pharynx see Fig. 3647.)

made postoperative complications exceedingly rare. Sloughing esophagitis, vagitis, or septic mediastinitis is evidenced by profound shock, weak and rapid pulse, slight temperature elevation, profound depression, and a white or ashy gray complexion. The treatment is by stimulants and local drainage of necrotic areas, but recovery is rare.

Artificial Larynx.—The most satisfactory apparatus is that of Sir Robert Woods, and next in efficiency is that of Glück. Most patients abandon the use of a prothetic apparatus and devote themselves to the development of a buccal voice.

Hemilaryngectomy.—If, at laryngofissure, one ring of the thyroid cartilage is too close to involved tissues to permit adequate removal by perichondrial dissection, half of the larynx may be excised with sharp shears. Or if preliminary laryngoscopy, direct and indirect, has revealed such a condition before operation, one side of the larynx may be removed by proceeding as in laryngofissure up to the point of exposing the interior of the larynx, then the excision of the wing of the thyroid on the involved side is completed with the scissors. The advantage of hemilaryngectomy over the total operation is that most patients are able to breathe through the mouth.

Against this, however, must be placed the cases in which stenosis occurs from collapse of the soft tissues on the operated side, and also the much greater operative risk from postoperative suppuration which is much more copious than in laryngofissure. The postoperative condition after laryngectomy and hemilaryngectomy is shown in Fig. 3647.

CHEVALIER JACKSON.

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4 Jackson, Chevalier Peroral Endoscopy and Laryngeal Surgery, 1914.

Laryngismus Stridulus.—See *Croup*.

Laryngitis.—ACUTE LARYNGITIS.—*Synonyms:* Acute laryngeal catarrh, pseudocroup, laryngorrhea, mucous laryngitis, sore throat. This is an acute inflammation of the mucous membrane lining the larynx, characterized by a moderate degree of exudation, with or without some slight febrile disturbance and more or less hemming or coughing. The characteristics of the disease in children differ somewhat from those of the adult, but these variations are not sufficient to require the separate study of the two classes, and they will therefore be considered here under a common title. In the adult acute laryngitis seldom threatens life, although the dyspnea and loss of voice are often unduly alarming to the patient. In childhood the disease occurs in three different forms, the mild, the severe, and the grave.

Etiology.—The most common predisposing cause is some pathological condition of the nose or nasopharynx, the occasional or continued mouth-breathing which accompanies these inflammations of the upper air tract rendering the larynx sensitive to the more immediate causative factors. The laryngeal mucous membrane in these cases of improper breathing is subjected to more irritation than is its due by the dry and unfiltered air which passes over it, and this induces a more or less severe chronic inflammation in this locality; and the various exciting causes of laryngitis then find a ready soil in the existing chronically inflamed membrane. The long-continued mouth-breathing to which one is subjected in a dentist's chair is a not uncommon cause of laryngitis. The disease occurs more often in males than in females, and more often in adult life than in childhood. It is more apt to be grave in children, and in them occurs oftenest between the ages of two and four years and with equal frequency in the children of either sex. Among the immediate causes of acute laryngitis are exposure to cold, depressed general vitality, inhalations of irritating dust, vapors, steam, or gases; the dust from our modern asphalted streets, the vapors of chlorine, iodine, ammonia, or sulphur, and the excessive use of alcohol are exciting causes. Overtaxing the voice by public speaking, singing, or shouting is a common cause. Wetting of the feet may be rated as one of the most frequent causes. Previous attacks make the patient more liable to subsequent ones. Among the general causes may be mentioned rheumatism, the eruptive fevers, influenza, and hay fever. The introduction of drugs like the iodide of potassium or atropine into the general economy or the introduction of various irritating drugs locally into the larynx may bring on an attack.

Pathology.—The pathology is similar to that of inflammations of mucous membranes elsewhere, there being a primary hyperemia with scanty secretion, the *dry stage*, and after that a second, or *moist stage*, caused by the pouring out of serum from the distended blood-vessels and the increased secretion of mucus from the glands. The desquamation of epithelial cells and the exudation of leucocytes give the whitish color and the tenaciousness to the secretion of the later stages. While there may be some desquamation of epithelium there are as a rule no deeper destructive changes. The swollen membrane encroaches on the breathing space, thus interfering to some degree with the respiration, and the dry feeling of the early stages adds to the discomfort. The inflammation may be general or confined to certain localities. The interarytenoid commissure shows the most decided changes and the ventricular bands or aryepiglottic folds come next. These areas show more marked changes because of the loose attachment of the mucous membrane to the subjacent tissue in these regions, and also of the fact that the unusual mobility of the commissure favors desquamation of the epithelial cells. The submucous layers are not often affected, the inflammation being more commonly confined to the superficial layers, and so too the supraglottic region is more often affected than the subglottic—which is fortunate, as the subglottic variety is accompanied by grave symptoms. In children the pathological changes are exaggerated; the exudation, being more plastic, becomes almost pseudomembranous; and, owing to the relative smallness of the breathing space, respiration is more severly interfered with, this resulting in stridor and spasms of respiration, which add to the gravity of these cases. The mucous membrane of the epiglottis does not as a rule show marked inflammatory change, but in chickenpox yellowish vesicles may appear in this region, while in measles and rötheln the mucous membrane partakes of the cutaneous characteristics. Stoerck described a "fissura mucosa" of the interarytenoid space which occurs when there is an erosion in this region, and the writer has seen at least two cases of this in which there was marked hemorrhage.

Symptoms.—The symptoms are somewhat more aggravated in childhood than in adult life. This is owing partly to the narrowness of the lumen in children, partly to the excess of lymph cells in their mucous membranes, and partly to the muscular deficiency which makes it more difficult for them to throw off the tenacious exudate. In the adult the chief complaint is the disturbance in vocalization, the voice becoming hoarse and husky or even completely lost, the degrees of loss depending upon the progress of the disease. Some tones can usually be elicited, but talking is difficult and requires a manifest effort. This is owing to the thickening and congestion of the mucous membrane which interferes with the proper approximation of the cords and with their resilience. The thickening of the arytenoid commissure and of the subglottic mucous membrane especially interferes with clear speech, and at times the ventricular bands may become so swollen as to lap over the true cords and add to the disturbance. It is possible that the loss of nerve tone also adds to the difficulty in controlling the muscles of speech, and at times too there seems to be a psychical element in the exaggerated speech deficiency.

Cough is an occasional symptom of acute laryngitis. This is due to the swelling of the mucous membrane and the excessive secretion in the later stages, but severe coughing usually implies an extension of the disease to the subglottic region or to the trachea or bronchi. The cough is apt to be harsh, metallic, and irritating, and may be due to congestion in any of the four cough centers. There may be some distress in the larynx accompanying attempts to speak or upon coughing, but this is not marked as a rule. There is not apt to be tenderness or pain externally, and respiration in adults is little interfered with except when there is a concurrent edema glottidis. Expectoration is scanty and serous at first, later becoming mucous and more copious and, when the bronchi are involved, mucopurulent and abundant. The constitutional symptoms when present are very mild in the adult, consisting of slight fever with

possibly some anorexia, headache, and general malaise.

In children the supraglottic variety is similar to the acute laryngitis of adults, but the subglottic form is more serious. The first marked symptoms are more often those relating to respiration. This becomes spasmodic and there may even be attacks of suffocation. These suffocative or croupous attacks occur more often at night and imply subglottic inflammation. The first night attack is apt to be the most severe, and although there may be subsequent attacks on three or four succeeding nights, each is apt to be less severe than its predecessor. These night exacerbations are brought on by the mouth-breathing. In the subglottic form cough sets in earlier, it is croupy in character and is probably due to the approximation of two opposite portions of swollen subglottic mucous membrane. The cough is harsh, dry, and husky, even when the child is aphonic. Children subjected to these attacks are especially apt to have lymphatic enlargements in the nasopharynx, or chronic inflammations of the nasal mucous membrane. One attack predisposes to another, and children are more apt than adults to have febrile disturbances.

Diagnosis.—The diagnosis is made from alterations in the voice, from the fact that the cough, if present, is dry, and not accompanied by secretion as in bronchitis, and from the absence of the constitutional symptoms present in syphilis, tuberculosis, etc. The most important aid to diagnosis, however, is the laryngeal image, by means of which laryngitis symptomatic of the more severe constitutional disturbances may be recognized or eliminated. This image can usually be obtained even in children. The writer has at times been enabled, in a child, to get a good laryngeal image with the largest size mirror, one inch and a half in diameter, when smaller sizes had failed. The laryngoscope reveals a generally red and congested mucous membrane, and this appearance is more marked in localities where the mucous membrane is loosely attached. The cords vary in color, they appear slightly thickened, and somewhat sluggish in their movements. The color of the mucous membrane varies from a delicate pink to a brick red, or a beefy color. The vocal cords may be pink or may show blood-vessels running over the elastic tissue or may be ecchymotic and show bleeding spots from the rupture of the capillaries due to coughing. This latter form is the so-called "hemorrhagic laryngitis." If the interarytenoid desquamation has been excessive a slit like a knife-cut may show in the median line, and this is apt to be found in cases of severe bleeding like the two referred to above. The fact that the vocal cords of public speakers are often habitually red must not be overlooked in making this diagnosis. There may at times be local desquamations in patches scattered irregularly over the surface of the mucous membrane. The changes in the interarytenoid space are usually the most marked. It is here that desquamation is more apt to be seen, and this region may in the later stages be covered by a tenacious mucus. In the subglottic variety the bulging subglottic mucous membrane may be plainly seen when the cords are abducted.

Differential Diagnosis.—From a study of the above-mentioned subjective and objective symptoms the diagnosis should easily be made. The possibility of diphtheria, measles, scarlet fever, or the more rare eruptive fevers, should be borne in mind. In the adult the diagnosis should be easy.

The *prognosis* is good as to recovery. The disease is never fatal in adults and rarely so in children, but if neglected it may become chronic or may lead to tracheitis or bronchitis.

Treatment.—In the early acute stages topical applications must be used with great care. Catharsis may be promoted by the mild chloride of mercury in half-grain doses combined with three grains of bicarbonate of sodium; this is to be repeated every two hours until it acts. The old "cold" remedies, quinine and Dover's powder, may be tried, together with a hot foot bath with or without mustard. A pleasanter and often more efficient remedy is aconite or aconitine in full physiological doses.

Local treatment consists in thorough though gentle cleansing of the mucous membrane of the upper respiratory tract followed by the application of sedative and astringent medicines. The nose and nasopharynx should be thoroughly cleansed by means of an alkaline antiseptic spray such as: ℞ Acidi borici, gr. v.; sodii bicarb., gr. x.; listerine, fl. ʒ vi.; aquæ destillat., fl. ʒ vi.; or a solution of Seiler's tablets; or diluted Dobell's solution may be used for this purpose. This should be gently blown out, care being taken to allow the nostril to be entirely free from external pressure during the blowing process. If the nasal mucous membrane is turgescent, a second spray should be used, something like the following: Cocaine hydrochlorate, gr. iiss.; acidi borici, gr. v.; aquæ destillat, fl. ʒ i. Just enough of this solution should be used to cover the turbinates and not enough to pass into the throat. This should be allowed to rest undisturbed for five minutes, after which a watery solution of suprarenal powder (gr. x.–ʒ i.) should be gently applied to the turbinates either with a cotton-tipped probe or in spray. The solution of suprarenal powder will decompose in a few hours, unless it be made more lasting by an addition of one-per-cent. resorcin or of some other preservative. An astringent and sedative solution, such as the following, may now be sprayed into the pharynx and inspired into the larynx: ℞ Ol. gaultheriæ, gtt. iv.; zinci sulph., or the larynx and nasopharynx may be painted with argyrol twenty-five per cent., gr. v.; antipyrin, gr. xx.; aquæ destillatæ, fl. ʒ ij. A small quantity of the powdered mild chloride of mercury barely sufficient to give them a grayish hue, may be insufflated over the turbinates, and finally the nares may be sprayed with an oily solution of ℞ Menthol gr. v., camphoræ gr. viii., liq. petrolat., fl. ʒ i.

After the mucous membrane has lost the extreme sensitiveness of the early stages a watery solution of sulphate of zinc, one to two per cent., may be gently applied to the laryngeal mucous membrane on a curved cotton-tipped probe. The above local treatment is usually all that is necessary in these cases and should of course be carried out by the physician himself. For home use the compound zinc solution above mentioned may be of service. It may be assisted by the inhalation of steam, which may be medicated by a solution such as the following: ℞ Menthol, gr. xv.; ol. eucalyptol, ʒ ij.; terebene, fl. ʒ iij.; tr. benzoin. comp., fl. ʒ iij., a teaspoonful of which may be added to a pint of boiling water. For the purpose of these steam inhalations a tin cup, spirit lamp, and paper cone are all that is necessary. The patient should not be allowed to expose himself to cold air for from half an hour to an hour after the use of steam inhalations.

The ice pack or Leiter's coil sometimes aids in allaying symptoms in the subglottic variety of acute laryngitis. Applications by the probe may be carried between the vocal cords into the subglottic region. These applications may be used to promote emesis in the croups of children and are superior for this purpose to the old-fashioned ipecac and mustard given internally, as they give the desired local effect without the constitutional after-disturbances.

Many methods have been suggested to clear the throat hastily of one who must use the voice in public. None of them, however, is infallible, and all of them are to be discouraged as far as possible. Rest of the voice and body in a room heated to a temperature of about 70° F. is among the best remedies for this. The air should be properly renewed and kept moist. The patient should drink freely of non-aerated water. The emunctories should be properly cared for, and alcohol and tobacco should be interdicted. The local treatment outlined above should be carried out. At times

the desired effect may be more quickly attained by the use of aconite or aconitine to the physiological limit, and by the application of the galvanic current to the external aspect of the larynx. Adrenalin chloride in weak solutions sprayed into the pharynx and inhaled into the larynx will temporarily clear the voice.

The supraglottic form of acute laryngitis in children is usually trivial, and a mild spray such as the compound listerine mentioned above may be used in the nose and throat. The Politzer bag may be applied to one nostril and compressed while the other is allowed to remain unobstructed; this forces the secretions from the nose and nasopharynx through the unobstructed nostril, then a large soft wad of cotton on the applicator may be soaked with a one- to two-percent. solution of sulphate of zinc and pressed against the pharyngeal wall; the zinc thus diffusing itself will have the desired effect of clearing the throat of excessive secretion, or argyrol in twenty-five per cent. aqueous solution may be applied to the nose, nasopharynx, and larynx after drainage of the ethmoid cells has been facilitated by shrinking the membrane with adrenalin and cocaine solutions. The child should be kept in a room the temperature of which is maintained at 70° F. and the air of which is kept moist by the croup kettle, slacking lime, or some similar device. Applications of camphor and oil of amber, or simply of suet, made locally over the bridge of the nose and the laryngeal region will sometimes be of assistance in these cases.

In the more serious subglottic variety of acute laryngitis, or pseudocroup, in children, more active measures are at times necessary. The routine treatment suggested above may be preceded by a general hot bath to which a small amount of mustard has been added. It may be necessary to pass the curved cotton-tipped probe into the larynx, emesis being brought about in this way. Hot water may be applied freely to the external throat by sponge or cloths. It must be borne in mind that these so-called croupy children have some defect of the nose or nasopharynx, and these defects should be corrected in the intervals between the attacks. As an adjuvant to the above a spray of suprarenal solution, gr. x.–℥ i., may be used in the croupous child every two or three hours. Hydrargyrum cum creta, or calomel and soda, when administered internally, aids materially in reducing the quantity of exudate. Tincture of chloride of iron and glycerin may be substituted for the zinc solution used above. In the more severe cases tracheotomy or intubation may be necessary; intratracheal injections of menthol-creosote and liq. petrolei may at times be of use in these cases of the subglottic variety. The possibility of Klebs-Löffler infection must be borne in mind and antitoxin promptly administered in positive or doubtful cases.

Edematous Laryngitis and Phlegmonous Laryngitis.—*Synonyms:* Edema glottidis; edema of the larynx, acute phlegmonous laryngitis, laryngeal cellulitis, purulent or suppurative laryngitis. Edematous laryngitis is an acute inflammation of the laryngeal mucous membrane, which is characterized by serous infiltration into the areolar tissue of the mucous membrane. It is at times idiopathic, or it may have a local cause, or it may be secondary to some general disease. In infected cases there may be pus formation resulting in the so-called phlegmonous laryngitis, the suppuration in these cases being unilateral as a rule. Edema is accompanied by the usual symptoms of distress caused by difficult breathing, and there may be some febrile disturbances. This disease occurs more often in the acute form, though it may at times become chronic.

Etiology.—Any disease which causes dropsy or anasarca in other parts of the body may cause an edema of the larynx. It has been said to occur idiopathically, but this form is probably the angioneurotic variety of Osler and others. Disease of the kidneys is one of the most common causes, since it is prone to bring about a venous turgescence in this region as well as elsewhere. Diseases of the heart, lungs, or liver which cause excess of venous pressure or damming back of the blood in the veins and consequent oozing of serum into the areolar tissue, may also bring about this laryngeal complication. External traumatisms, or foreign bodies in the larynx or the neighboring esophagus, or the inhalation of irritating gases, vapors, or fluids are at times causes. The edema may be secondary to tuberculosis, syphilis, scarlet fever, diphtheria, typhus or typhoid fever, smallpox, or streptococcal infections. In the phlegmonous variety some septic condition is likely to be

Fig. 3649.—General Edema of the Larynx. (Browne.)

the cause, such as erysipelas, tonsillitis, or pericervical inflammation. The angioneurotic edema is probably caused by vasomotor paresis due to a general neurotic condition.

Pathology.—There is a primary engorgement of the vessels and later a consequent leakage of serum into the perivascular areolar tissue; rarely this fluid is sanguineous. This leakage is naturally greater in the localities where the tissue is loosest, so that the most marked swellings are in the ventricular bands and the posterior surface of the epiglottis and to a lesser degree in the interarytenoid commissure. The epiglottis is nearly always involved, while the vocal cords are not often affected, nor is the subglottic region

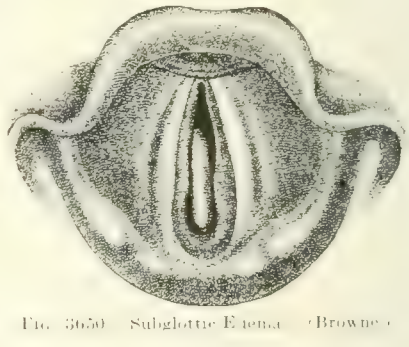

Fig. 3650.—Subglottic Edema. (Browne.)

as a rule. In the phlegmonous variety the exuded serum undergoes purulent change and an abscess is formed; and while, in the ordinary variety, the swelling is symmetrical, in these cases it is usually unilateral (Fig. 3650). At times the surrounding cervical tissues may become infiltrated with serum.

Symptoms.—The prominent symptoms are the dyspnea, the impairment of the voice, the cough, and at times orthopnea. The dyspnea comes on suddenly as a rule, reaching its height in about thirty-six hours from its onset. Inspiration in the severe forms is more difficult than expiration, owing to the rolling in of the swollen mucous covering of the ventricular bands and epiglottis. The voice becomes deep and may later be lost entirely. The cough is very wheezy

and labored, brings no relief from the symptoms, and is accompanied by but little expectoration. Pain is not usually present, although it may be experienced on swallowing or when the cervical tissues become infiltrated. As in other diseases which obstruct the breathing, the patient wears an anxious look, is usually restless, and is more comfortable in the sitting posture than when lying down. In the phlegmonous variety there is apt to be fever or even a chill. The laryngoscope reveals a swollen mucous membrane, smooth, glassy, and semitranslucent, not unlike the appearance of a myxomatous polyp. There are usually three prominent projecting folds formed by the epiglottis and the two aryepiglottic folds. Between these three folds is a triangular opening in which it is at times possible to see the true cords and the interarytenoid commissure. When the use of the laryngoscope is impracticable, which is rare, a digital examination may be necessary to disclose the true condition.

The *diagnosis* is made from the above symptoms and signs.

Treatment.—The local symptoms should be relieved by scarifications which may be made with the laryngeal scarifier (Fig. 3651) or with an ordinary curved bistoury protected close to the point with a wrapping of adhesive plaster. A solution of suprarenal powder, sulphate of zinc, or nitrate of silver may be applied to the swollen mucous membrane. External applications of cold by means of the ice pack or Leiter's coil, may be of service. Free diuresis, catharsis, and diaphoresis should be promoted. For the latter purpose pilocarpine may be administered. The underlying constitutional symptoms should be treated according to the general principles laid down in each case. In a case recently seen by the writer prompt relief of the laryngeal condition followed artificial premature labor which was induced for the relief of the kidney symptoms. It may at times be necessary to resort to tracheotomy or intubation to save life. In these cases the former is usually to be preferred, as the relief is more rapid and is usually brought about with less inconvenience to the sufferer.

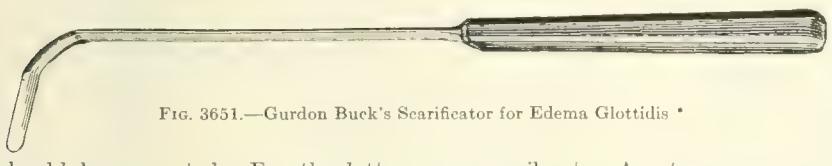

Fig. 3651.—Gurdon Buck's Scarificator for Edema Glottidis *

Chronic Laryngitis. This is an inflammation of the laryngeal mucous membrane, of long standing and gradual development, characterized by hemming, hoarseness, and cough. It occurs more frequently in middle age, and men are more prone to suffer from it than are women. It frequently follows inflammation of the nose and nasopharynx, and is often present in chronic conditions, such as tuberculosis or syphilis. Nevertheless, when present in tuberculosis or syphilis the laryngitis need not necessarily be tuberculous or syphilitic, but may be of the chronic catarrhal variety intercurrent with the systemic malady, and in such cases often yields to the usual treatment outlined for chronic catarrhal laryngitis.

Etiology.—Chronic laryngitis may be a sequel of the acute form, or may be an extension from the pharynx. The most common causes are the chronic obstructive lesions of the nose and nasopharynx. Posterior ethmoiditis is a frequent cause. An elongated uvula is often cited as a cause, but as the elongation itself is usually caused by a postnasal lesion or a prolonged cough, it is really included under the nasal causes. Papilloma of the uvula is a rare cause. Cryptic, caseous faucial tonsils, or those containing pus pockets, sometimes induce this laryngeal condition.

Chronic laryngitis may be vocational, as when caused by irritating vapors or dust, or sudden changes in temperature, as in those employed in ice-houses and cold storage rooms. The excessive use of alcohol may cause laryngeal inflammation, and, to a lesser degree, the use of tobacco, although the latter must be only a contributing factor, as the excessive smoker in the tropics rarely suffers from chronic catarrhal laryngitis. It probably only lowers the resistance of the laryngeal mucous membrane to the attack of other causative factors, by its depressing influence upon the central nervous system. The excessive use of tobacco may delay a cure, however.

A not uncommon cause of chronic laryngitis is the improper use of the voice, especially in singers and public speakers.

Irritating foreign substances in the external auditory canals occasionally give rise to cough from the communication between the postauricular and the auricular branches of the vagus, and thus cause chronic inflammation of the larynx.

Among the constitutional diseases accompanied by chronic laryngitis are, tuberculosis, syphilis, gout, rheumatism, nephritis, carcinoma, and abnormalities of digestion.

Pathology.—There is a small round-cell infiltration, and a proliferatoin of connective tissue, which may pervade the entire mucous membrane, or may occur only in certain portions of the larynx. The round-cell infiltration may be seen in all layers of the mucous membrane. At times the hyperplasia of the epithelial layers gives rise to warty growths or pachydermia. These tissue charges give rise to different macroscopic appearances of the larynx, depending upon the particular portion of the larynx in which the changes have been most extensive. Thus the surface of the vocal cords may present a lumpy or tuberous appearance (chorditis tuberosa, or trachoma). Or there may be nodular enlargements on the edges of the vocal cords, generally at the junction of the anterior with the middle third (singers' nodes). Or, there may be polyp formation. At times there is a distinct subglottic hypertrophy. There is usually marked roughening and thickening of the interarytenoid space, with desquamations and erosions in this region, even without the presence of syphilis or tuberculosis. When the muscles become affected, either from the thickened fibrous tissue, or from intrinsic involvement, there is paresis or paralysis. The *secretion* may be excessive and purulent (chronic blenorrhea), or it may become dried into crusts or scabs (laryngitis sicca,

* The author's description of the procedure is quoted here in full. "The patient being seated on a chair, with his head thrown back and supported by an assistant, he is directed to keep his mouth as wide open as possible; and if there be any difficulty in this respect a piece of wood an inch and a fourth in width and half an inch in thickness, is to be placed edgewise between the molar teeth of the left side. The forefinger of the left hand is then to be introduced at the right angle of the mouth, and passed down over the tongue till it encounters the epiglottis. But little difficulty is generally experienced in carrying the end of the finger above and behind the epiglottis so as to overlap it and press it forward toward the base of the tongue. In some individuals the finger may be made to overlap the epiglottis to the extent of three-fourths of an inch. Thus placed, the finger serves as a sure guide to the instrument. The knife is then to be conducted, with its concavity directed downward, along the finger till its point reaches the finger-nail. By elevating the handle so as to depress the blade an inch to an inch and a half farther, the cutting extremity is placed in the glottis between its edges; at this stage of the operation the knife is to be slightly rotated to one side and the other, giving it a cutting motion in the act of withdrawing it. This may be repeated two or three times on either side without removing the finger. The margin of the epiglottis, and the swelling between it and the base of the tongue, may be scarified still more easily with the same instrument, or scissors, curved flatwise, may be employed for these parts, guided in the same manner as the knife."

or dry catarrh). The secretions may be intrinsically formed in the larynx, or may come from the trachea or the pharynx and nasopharynx. When the secretions are very profuse an accompanying bronchitis may be suspected. The above changes, and the macroscopic appearances described under *Diagnosis*, are all due to different arrangements of the round cells, or the fibrous tissue hyperplasias; that is, they are only different manifestations of the same pathological process.

Symptoms.—The most common symptoms are a "feeling of fulness," an irritating tickling cough, or constant hemming and clearing of the throat, accompanied at times by a burning or dryness in the larynx, and, finally, alterations in the voice, or hoarseness. There may be a sense of fatigue in the larynx, and at times a general fatigue out of proportion to the importance of the disease. The voice alterations are due to scantiness of secretion, scabs, excess of secretion, pathological changes in the vocal cords, muscular insufficiency, or to interarytenoid fibroid thickening, preventing the proper approximation of the cords.

Diagnosis.—The diagnosis is made partly from the symptoms, but more especially from the laryngeal image, always bearing in mind the widely differing appearances of normal larynges.

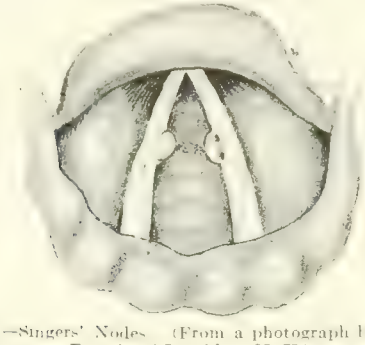

Fig. 3652.—Singers' Nodes. (From a photograph by Dr. T. R. French, of Brooklyn, N. Y.)

The laryngeal mirror reveals more or less redness of the lining mucous membrane. There may, or may not, be an excess of mucus. When present, the mucus is more evident over the posterior commissure, or, in the atrophic form (laryngitis sicca), the mucus clings tenaciously in dry cakes over the posterior commissure of the vocal cords, or in the subglottic space. The removal of the scabs may be accompanied by slight bleeding (hemorrhagic laryngitis). The posterior laryngeal wall or interarytenoid space usually shows some thickening, and at times the thickening projects into a distinct ridge or lump, which is flattened during inspiration, but which impedes the approximation of the vocal cords, and adds to the hoarseness. At times (rarely) there are present slit-like, vertical grooves or fissures in the interarytenoid thickenings, and from these there is occasionally rather free bleeding, giving rise to unnecessarily bad prognoses on the part of the internist or specialist unfamiliar with this form of bleeding. These roughened interarytenoid spaces also sometimes show desquamations or erosions, even in simple catarrhal laryngitis. At times either one or both edges of the vocal cords are serrated. Occasionally, and especially in singers or those who use the voice excessively, who have overstrained their voices, small nodules are seen on one or both vocal cords, at the junction of the anterior and middle third of the cord (Fig. 3652) a condition known as "singers' nodes," choriditis nodosa, vocal nodules, trachoma, or chorditis tuberosa. These nodes are occasionally found in children who have strained their vocal cords by improper use. In such cases they cause hoarseness, but do no other harm. Indeed, these singers' nodes may occasionally be found without other evidence of chronic laryngitis. At times there is a grayish thickened plate posteriorly on one vocal cord, which laps over and rests on a small depression on the other thickened vocal cord (pachydermic laryngitis). These pachydermatous warty nodes may appear eroded and fissured. Another rather rare appearance is that of the hyperplastically thickened mucous membrane projecting into the laryngeal lumen, and presenting the appearance of a "prolapse of the ventricle."

In the subglottic variety of chronic laryngitis the inferior surface of the vocal cords is thickened into pads which project into the lumen beyond the elastic cord edges.

The *differential diagnosis* must be made between chronic catarrhal laryngitis and tuberculosis, syphilis, or carcinoma; and the possibility of the simple chronic catarrhal process coexisting with a general tuberculous or syphilitic condition, must be borne in mind.

A pale mucous membrane, with paresthesiæ or ulcerations below or behind thickened elevations, seen in the laryngeal mirror or through the laryngoscopic tube, suggests tuberculosis. Here, the lungs, sputum, and urine should be examined for confirmatory evidence, and, if negative, the course of the disease carefully observed, when, if the laryngitis is slow to respond to treatment, tuberculosis may still be suspected. Paralysis of the vocal cords is not significant of tuberculosis.

Syphilitic laryngitis is rarely primary. The erythema of the laryngeal mucous membrane is more dusky red, edematous at times, while the infiltrations, papules, gummata, ulcerations, stenoses, and cicatricial changes of the later stages of syphilitic laryngitis are unmistakable. Apart from this the Wassermann test, and the recognition of the *Spirochæta pallida* establish the diagnosis of syphilis.

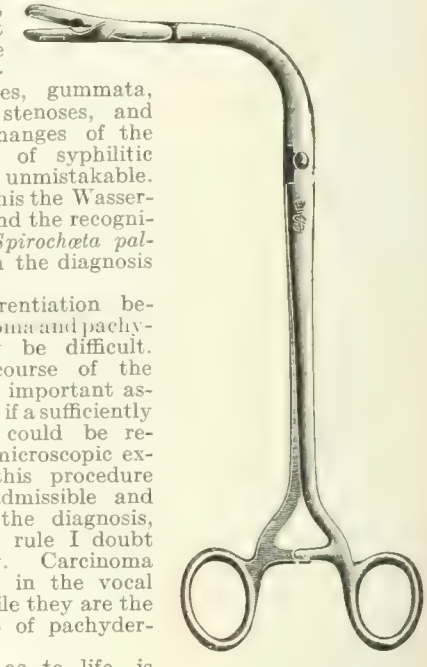

Fig. 3653.—Ruault's Cutting Laryngeal Forceps.

The differentiation between carcinoma and pachydermia may be difficult. Here the course of the disease is an important assistance, and, if a sufficiently large mass could be removed for microscopic examination, this procedure might be admissible and might clear the diagnosis, though as a rule I doubt its efficiency. Carcinoma never occurs in the vocal processes while they are the favorite seat of pachydermia.

Prognosis, as to life, is excellent; as to cure, with occasional more or less prolonged relapses, it is good. Where there is marked muscular deficiency, or pachydermia, the prognosis as to permanent relief is not so good. As to the continued usefulness of the voice in singers, actors, and other voice-users, the prognosis need not necessarily be bad, even when severe lesions are present, as the most ragged, hypertrophied, and inflamed-looking throats will sometimes emit fine, or at least unobjectionable, and lucrative tones for years.

Treatment consists in regulation of hygiene and diet, and general supervision of emunctories is of

course important. Excessive eating, or undereating; excessive use of alcohol or tobacco, must be guarded against. The term "excess" however, is distinctly relative and varies with the individual. Climate or water cures may, at times, be serviceable. Exposure to cold and wet, wet feet, and dusty or irritating fume-laden atmospheres, are to be avoided. Carbonated wines or waters seem to irritate in many cases. The proper use of the voice, avoiding strain of the intrinsic laryngeal muscles, is important. The nasal and pharyngeal tracts should be made as nearly normal as possible, and freed of all elements irritating to the larynx. The nose should be opened, and the sinuses and ethmoids properly drained and aerated. The nasopharynx and pharynx should be cleared, always bearing in mind that operations may work harm in a given case, and remembering that singers, lecturers, and others dependent upon their voices, often have learned to use their voices with the existing pathological conditions, and a radical operative change might disturb the accustomed equilibrium.

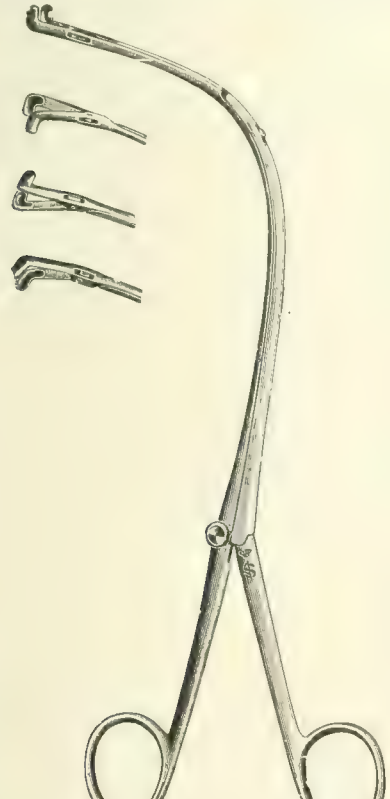

Fig. 3654.—Scheinmann's Cutting Laryngeal Forceps.

The checking of a posterior ethmoiditis is often the most important step in the treatment, and it should be followed, or accompanied by, local applications into the larynx. Such intralaryngeal medication includes the mineral astringents, but in the dry form of laryngitis inhalations are first used to loosen the scabs, and the astringents are applied to the cleansed surface of the larynx later. An aqueous solution of zinc sulphate one to two per cent., zinc chloride in weaker solutions, and argyrol, twenty-five to fifty per cent. are indicated. Or, the old iodine gr. vii., potassium iodide gr. xvi, and glycerin and water āā ℥j ss may be used. Of these solutions the zinc sulphate, applied on a curved, cotton-tipped applicator, directly to the cleansed interarytenoid space, and even below the vocal cords, is very efficacious in thinning out the hypertrophy and healing the erosions, although at times in selected cases, it may be better to use nitrate of silver, or lactic acid. The stronger cauteries (chromic acid, trichloracetic acid, or the actual cautery) are especially efficient in pachydermia; or, in extreme cases, surgical extirpation may be necessary by means of the Krause double curette. So, too, in urgent cases, it may be necessary to cut out singers' nodes with the curette or forceps shown in Figs. 3653 and 3654.

In certain selected cases the diagnosis, and especially the treatment of these cases may be aided by the use of the direct laryngoscopic appliances.

George C. Stout.

Laryngofissure.—*Synonym:* Thyrotomy. The operation of dividing the skin externally over the larynx and splitting the thyroid cartilage down the median line to gain access to the interior of the larynx. It is usually done for malignancy.

History.—Thyrotomy was first done by Brauers of Louvain, though it was previously proposed by Desault. Recurrences of malignancy were so frequent that the operation was universally condemned until it was taken up and established on a firm basis by Sir Felix Semon, who showed conclusively that the previous bad results were due to improper selection of cases for the operation.

Indications.—Thyrotomy is indicated in any case of malignant disease of the larynx in which the involvement is intrinsic (*i.e.* not higher than the ventricular band), and in which the involvement is so slight that there is practical certainty that all of the growth may be removed by cutting through normal tissue and not through neoplastic tissue. Therefore the cancer must not only be intrinsic but it must be of very limited extent. Fixation of the cricoarytenoid joint renders party-wall invasion probable and, if long continued, a recurrence will probably follow operation.

Contraindications.—A very high grade of malignancy, as shown by rapid local growth, is a contraindication to any operation other than palliative, because recurrence is certain. The same is true of cases with extension beyond the intrinsic area, of which the upper edge of the ventricular band is the limit. Metastatic foci, feebleness, organic disease, alcoholism, and pyorrhea alveolaris render any attempt at operative cure of malignancy inadvisable.

Operation.—*Preparation of the Patient.*—The patient should be prepared as for any other operation with a bath, laxative, etc.; but in addition it is absolutely imperative that the mouth be thoroughly cleansed with antiseptics of which twenty per cent. alcohol is preferable because non-toxic; and the teeth should be put in good order by a dentist, to minimize the risk of oral sepsis. The beard and moustache should be removed if the patient have these.

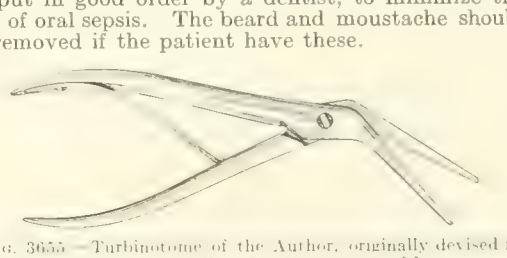

Fig. 3655.—Turbinotome of the Author, originally devised for turbinotomy but found excellent for thyrotomy and laryngotomy.

Position of the Patient.—It is essential that the patient be in a reclining dorsal position, the neck over a sand bag and the head-end of the table lower than the foot, in order that gravity shall resist the aspiration of blood into the trachea and bronchi.

Instruments.—Besides ordinary operating instru-

ments it is necessary to have a turbinotome (Fig. 3655) or some other form of heavy shears. An electric headlight is of great aid.

Anesthesia.—Local infiltration anesthesia by the intradermatic injection of normal salt solution containing a minute quantity (one-tenth of one per cent.) of cocaine will enable the operator to reach and lay bare the thyroid cartilage without pain. The interior of the larynx, however, is best anesthetized before operation by direct laryngoscopy, an extra pair of gloves being used to prevent infecting the under-gloves to be used later in the external operation. This obviates the necessity of infiltration of the intralaryngeal tissues, but the anesthesia is so evanescent that the operation must promptly follow. The author prefers intratracheal insufflation ether anesthesia, as devised by Meltzer and modified by Elsberg and others. The anesthetist is out of the way, the anesthesia is under perfect control, the cough reflex can be abolished for a few moments at a time and promptly brought back, the duration of the operation is very much lessened, and, most important, the return flow of air and ether prevents all possibility of blood being aspirated down the trachea. The insufflation catheter is not at all in the way in the interior of the larynx, as shown in Fig. 3656, and can be moved laterally out of the way if desired. A tracheal cannula placed in a tracheotomic wound and surrounded by packing has been used by some operators for the continuation of a general anesthetic started in the regular way.

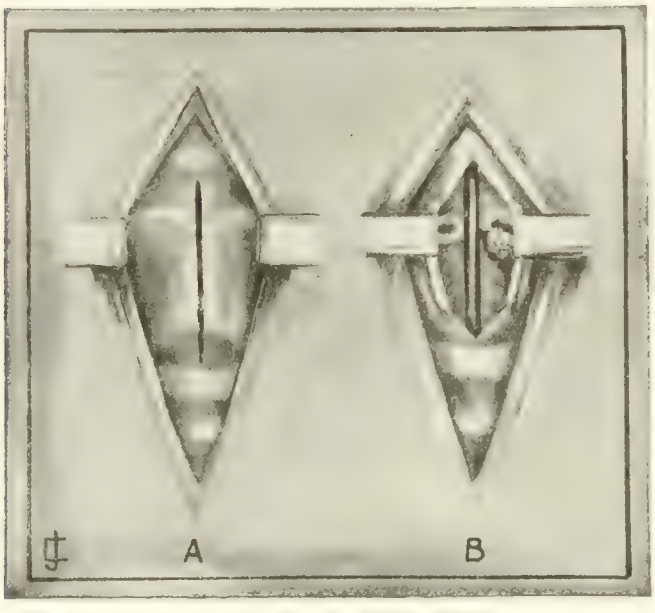

Fig. 3656.—Illustration of Thyrotomy or Laryngofissure. *A* shows the line of incision through the thyroid cartilage. *B* shows the interior of the larynx exposed by retraction of the divided chondrial wings. A growth is shown on the left vocal cord.

Technique.—The skin of the front of the neck is sterilized by the application of iodine in the usual way. An incision is made through the skin and subcutaneous tissue, in the center line of the neck, extending from about two centimeters above the upper border of the thyroid cartilage to about four centimeters below its lower border. The thyroid and cricoid cartilages are quickly laid bare, but great care is taken not to elevate or otherwise damage the outer perichondrium. An incision is made in the cricohyoid membrane and the lower blade of the turbinotome (Fig. 3657) is inserted upward into the larynx sufficiently far to divide the thyroid cartilage at one clip. In making this clip it is essential in cases of growths that are known to be close to the anterior commissure, to make the cut sufficiently to one side to avoid cutting through the growth. In some instances it may be found necessary to split the cricoid cartilage, though as a rule this should be avoided. In reoperations the old incision must be followed. The lateral rings of the thyroid cartilage are spread with retractors, using these with care to avoid trauma to the edges of the cartilage. The interior of the larynx is thus brought into view and it is noted that there are no thin white bands corresponding to the image of the vocal cords as seen on laryngoscopy. The landmark is the ventricle of the larynx which is situated above the cord. A tethered tampon is used to plug the pharyngeal orifice to keep the oral secretions out of the larynx. The inner perichondrium is now dissected from the thyroid cartilage on the involved side, the growth being removed in the form of an island resting in the center of a large area of normal tissue, using knife and scissors as seem best suited. Great care is needed to avoid injury to the arytenoid motor mechanism, though of course this should not weigh against adequate removal of a sufficient base of healthy tissue. Care is taken at each step of the operation to keep the wound as dry as possible by careful hemostasis. After the excision there are usually some small vessels to be twisted or tied. The tethered tampon is then removed. The skin incision may have a stitch at its upper and another at its lower end, but the balance of the wound should be left open. In the author's experience any attempt to stitch the divided wings of the thyroid cartilage results in serious damage to the cartilage following failure to hold. The wings of the cartilage are seen to spread at each swallowing movement but there will be no malposition in healing if the method of dressing developed by Dr. Patterson and the author be followed. The wound external to the larynx is packed open by spreading over the entire front of the neck a triple layer of gauze, into which, at the site of the wound, rolls of gauze are stuffed firmly (Fig. 3658). By this method the wound is kept open without risk of ends of packing getting down into the larynx or trachea. By this time the patient should be completely out from under the anesthetic, the later stages having the insufflation of air only. The insufflation catheter is now removed, and the patient should breathe normally through his larynx.

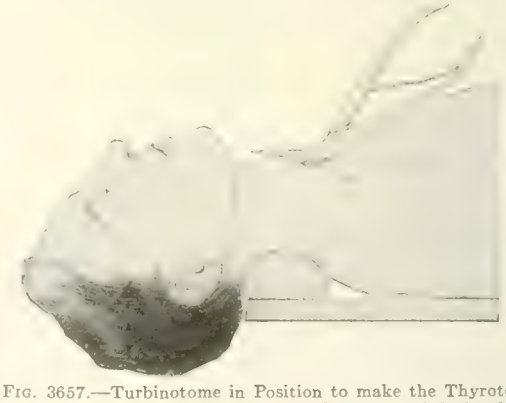

Fig. 3657.—Turbinotome in Position to make the Thyrotomic Clip. The table is not shown steeply inclined toward the head as it should be before the turbinotome is inserted.

After-care.—The patient should be placed in bed upon his back with sand pillows on each side of his head in order to keep the head straight in the median line, to prevent lateral traction on the laryngeal cartilages that would occur if the head should be rotated. After forty-eight hours the sand bags may be dispensed with and the patient permitted, at intervals, to turn the head for a few minutes of rest. The patient is usually allowed to sit up in bed on the

Fig. 3658.—Author's method of Packing Tracheal and External Laryngeal Wounds to Keep them Open. A double thickness of gauze is spread over the whole front of the neck. The portion over the wound is then tucked into the wound. Then a little hard roll of gauze is forced into the wound carrying the double layer with it. This form of dressing prevents any ends from getting down into the trachea. Useful in dressing laryngostomies, thyrotomies, and tracheotomies.

third day and to get out and move about on the fourth. He must be closely watched by nurses skilled in tracheal work who can put in a tracheal cannula promptly if the patient should develop any difficulty of breathing. They also change the dressings every third hour or oftener if necessary. By constantly thus removing air-infected secretions a practically aseptic wound is maintained. The food should be sterile liquids for the first four days. The patient may use his voice for a few minutes three or four times a day for a week, after which moderate use of the voice is advisable. Healing is usually complete in three or four weeks, the wound being compelled to heal from the bottom. The cartilages never unite, but firm fibrous union must be obtained before allowing the external wound to close. A little suspicious appearing fungation may be noticed on laryngoscopy for a month or more. Should this persist it may be removed by direct laryngoscopy (See vol. ii, p. 531) for examination, before deciding upon opening up the external wound for a recurrence.

Mortality and Results.—Statistics are very faulty because many cases of thyrotomy are reported in which it is clear that the operation was contraindicated. If the operation is strictly limited as mentioned in the section on Indications the results are better than operation for malignancy in any other region. Representative results are those of Sir Felix Semon, with eighty-five per cent. of lasting cures. Fifteen of his cases were known to be well after periods varying from three to sixteen years. The results of Sir St. Clair Thomson, Herbert Tilley, Chevalier Jackson, and others who limit their operations strictly to intrinsic growths of limited extent corroborate the great curative efficiency of laryngofissure in laryngeal malignancy. The mortality of the operation is exceedingly slight. Sir Felix Semon reports three deaths out of twenty-two cases, only two of which could be justly attributed to the operation. Other operators, using Semon's technique, have reported a large series of operations without a single operative death. Recurrences are, of course, usually reoperable by thyrotomy or laryngectomy. Reappearance of malignancy of the same or of another type of cell, in a situation remote from the site of operation, some years thereafter, may be regarded as a reinfection of a vulnerable soil rather than a repullulation of the primary process. The vocal results after thyrotomy are remarkably good, and we are justified in promising the patient that he will have, ultimately, a good loud voice. It may be slightly altered in pitch and, if the arytenoid motility has been interfered with at operation, the flexibility of the voice will be very much impaired. A good singing voice has been obtained in a number of instances. As demonstrated by the author, motility of the cricoarytenoid joint is the chief factor, by traction on the cicatricial tissue, in the formation of an adventitious vocal cord. With unimpaired arytenoid mobility the adventitious cord ultimately, becomes, in many instances indistinguishable laryngoscopically from its natural fellow. (Fig. 3659.)

Complications.—It sometimes happens that when the larynx is opened the growth is found much more extensive than was anticipated, involving the "party-wall," or that the cartilage has become involved by the associated mixed infections. The operation must then be abandoned and either a tracheal cannula put in by way of palliation, or a partial or total laryn-

Fig. 3659.—The Left-hand Illustration Shows an Indirect View of Larynx Eight Weeks after Thyrotomy for Cancer of the Right Cord in a Man of Fifty Years. At the right is shown the same condition after two years. An adventitious band indistinguishable from the original one has replaced the lost cord.

gectomy must be done. To proceed with the thyrotomy not only does not benefit the patient but it brings into disrepute a valuable curative operation for a properly selected case. Necrosis of cartilage, especially the anterior edges of the thyroid cartilage, may follow thyrotomy especially if the external perichondrium has been damaged or the cartilage itself has been injured by stitches or otherwise. In case of reoperation an island of cartilage may die if the line of fibrous union of the previous incision be not accurately followed. Lung complications after thyrotomy by modern methods are exceedingly rare.

Chevalier Jackson.

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Laryngoscopy.—For the examination of the larynx by the older, or indirect method, it is essential that one should have a head mirror or reflector, which may be self-illuminated, as by electricity either from a wall plate or a small storage battery, or which may reflect light from kerosene, gas, or electric lamp, or which may use the direct rays of the sun. We are indebted to Czermak for the use of this valuable instrument with artificial light. Tuerck first used the reflector and both he and the discoverer of the laryngoscope, Manuel

Garcia, used the direct rays of the sun to illuminate the larynx. These events took place in 1855–57.

For general routine examination and work, the form of reflector most used is a concave mirror attached by ball and socket to one form or another of band. This last is usually placed firmly around the head, and keeps the mirror properly in place, after it has been adjusted. It is intended that the reflector should be so used that the right eye can look in a straight line through the hole in the center of it, at the object to be illuminated. The reflector is perhaps three and one-half inches in diameter, and has a focal distance of from eight to ten inches, this last fact being one which should never be forgotten by the beginner or by the presbyopic. If one has any marked error of refraction, and does not wear glasses constantly, it is very convenient to have a lens attached to the back of this mirror, arranged so that it can be moved over the opening when desired. Such a reflector as the one described is the one which is in mind in the statement of how to perform indirect laryngoscopy which follows.

The second essential for indirect laryngoscopy is the small, usually round mirror, the laryngoscope proper, which is of plane glass and set at an obtuse angle with its long handle. In general, one should use as large a throat mirror as can be accepted conveniently by the patient, as it keeps the uvula out of the way and gives a fuller view of the larynx region in one picture, avoiding the necessity of moving the mirror once it is in proper position.

The patient is placed with his back to the light, which when artificial should be about a foot from the head, and on a level with his right ear. Whereas daylight or the direct rays of the sun may be used, as before said, it is the rarest exception to do so, and usually it is any good gas or electric lamp which may be condensed by a lens, before being received on the reflector or not, according to the habit or wish of the examiner. The latter should sit at the right of his patient, and preferably entirely at his side, and not with the patient's knees between his, as is so often done. In examining patients for the first time and in general invariably the next step will be, after adjusting the head mirror so that the reflected light falls on the lips of the patient, to request the latter to open his mouth and say "ah." While so doing the examiner sees that his reflector focuses accurately upon the base of the uvula and the patient has bent the head back a little from the usual upright position. Usually, as the examiner's eye must be on the level of the patient's mouth, it is better if the latter sits a bit higher than the examiner; otherwise the examiner must bend to a lower position, which makes it awkward for him to work. Having, either with or without the tongue depressor, achieved a good view of the uvula and back of the mouth or pharynx, the operator next warms the throat mirror, either by dipping it in a warm antiseptic solution or by holding it over the gas flame, or that of an alcohol lamp if electricity is used, with the glass toward the flame until the steaminess first caused by so placing the mirror has left its surface. The examiner, after trying the back of the mirror on the back of his own hand to be sure that it is warm enough and not too warm, then grasps it in his right hand in such a manner as to keep the cleaned surface of the mirror away from the patient's face, and proceeds to lay a bit of gauze or a small napkin on the patient's protruded tongue. This gauze should be neatly laid around the tongue and then the latter grasped by the examiner's left hand with the fingers under and the thumb above, as shown in Fig. 3660. With a simple movement of the fingers of the right hand the throat mirror is shifted to the grasp of the thumb and first fingers. If it is held correctly the fingers will be in the position in which a pen is usually properly held. The thumb and fingers should be semi-flexed so as to allow of a slight flexion and extension as may be desired later. The grasp should not be too firm as this keeps the fingers stiff and too rigid. If this process takes too long the mirror will cool, and must be warmed again. Some examiners prefer always to grasp the tongue before warming the mirror. This is perfectly feasible if the warming

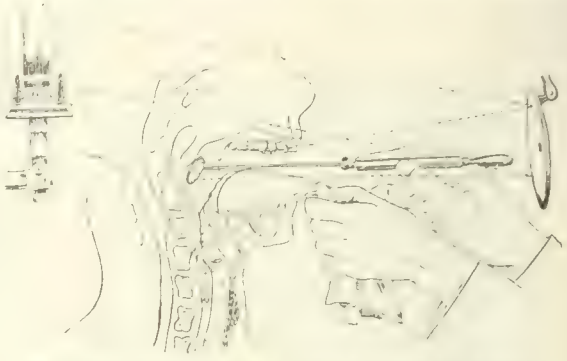

Fig. 3660.—Shows Manner of Holding Tongue and Mirror

lamp is easily at hand. It is possible to use a smear of a soap-like substance to cover the mirror so that warming is not necessary each time, but this is not as satisfactory on the whole as the usual warming method. During all of this, whether the mirror is warmed before or after the tongue is grasped, if the patient takes his position as directed and the head mirror has been properly adjusted, the light will be reflected properly into the back of the mouth and be where it is needed during the introduction of the throat mirror and the subsequent glimpse of the interior of the larynx. The throat mirror should now be carried, with its back and shank up, the mirror above but not touching the surface of the tongue which would blur it, until the base of the uvula is reached. The hand is then rolled outward, the shank of the mirror thus coming into the corner of the mouth. This should make the surface of the mirror square in front of the examiner, at right angles to the rays of light coming from the head mirror. If the patient's tongue is well protruded and he has breathed through the mouth while the mirror was being introduced, one should see in the mirror at this point the picture of the upper end of the epiglottis and its relation to the base of the tongue, but this will occur only if the mirror is flat and square across the throat. At this juncture the patient is requested to say "ay," as in "pay" or "say," and in as high pitched a tone as possible. As the larynx rises to take the high note the vocal cords will be seen in the mirror often without any motion, or perhaps it will be necessary to give the mirror a slight tilt either higher or lower to make the desired picture clearer. Unless the mirror is proportionately large and the epiglottis quite erect, it is seldom that one sees the whole larynx at any one moment, as is shown in Figs. 3661 and 3662. But this can be readily accomplished while the tone is being sustained by the patient by a quick motion of the fingers, especially if, as already stated, these same fingers are in a semiflexed position allowing of quick motion, and if the mirror is not being held too rigidly by the examiner, two mistakes very often made by beginners. After the patient has said "ay" as long as he can, he is told to take a deep breath, and as the vocal cords fly apart a quick motion of the throat mirror adjusts it so that it is possible to see down between them into the larynx, and if the light is good and well focused, in favorable cases, a view may be had way down as far as the bifurcation of the trachea. If the examining eye is directly behind the hole in the head mirror, if the light is accurately focused upon the base of the uvula and thus on the throat mirror,

if the latter is still clean and warm and rightly placed so that the rays of light reflected from it go down into the throat in the median line, if the patient's tongue is well protruded, and if he says a high-pitched "ay" (not "ah" as in "father"), then one must at least see the epiglottis if it exists and some of the interior of the larynx on the first introduction of the mirror. Usually one should expect to see without fail the whole interior of the larynx. However, it is better not to try to see too much the first time; it is much better to go into the patient's throat several times briefly than to have stayed too long and gagged the patient perhaps even to vomiting, as may readily occur. This gagging happens all too easily under the most favorable circumstances, and is frequently the result of the examiner's carelessness, too much traction on the tongue, too great movements of the mirror, too much pressure on the palate and back wall of the throat, general lack of skill, or it may be entirely emotional on the part of the patient, or because his breathing is not quiet and continuous. The patient should always take a deep breath right after saying the first "ay" rather than repeat the vowel before breathing again.

To have a correct understanding of the pictures which one sees in the mirror one must always bear in mind the inversion of the image, as is shown very clearly in Fig. 3661. In children one often fails to see the interior of the larynx well because the epiglottis is so prone, being bent so far backward that protrusion of the tongue or high pitching of the voice will not raise it enough to show the vocal cords. This is often true even of the adult larynx, especially when the adult form of the epiglottis is not attained and the contracted infantile type is retained through life. This is practically always true of a patient under a general anesthetic and then *direct* laryngoscopy is greatly ahead. In health the glistening white vocal cords spring into view back of and below the epiglottis and serve as a point of departure. Depressing the handle of the mirror will tilt it so that we can see the arytenoids touching each other during phonation or flying apart as the cords separate during inspiration. In making an examination it is quite important that one should take into consideration the character of the motions of the cords in both directions, for clinically it is quite as bad for them not to fly apart as it is that they should not come together. One might overlook important trouble if he only viewed the cords in the position of phonation. The anterior commissure is also often difficult to see, and to see this well one may have to hook the epiglottis forward —naturally only in a cocainized subject. To see well down into the trachea or on the posterior wall of the larynx the examiner must be well below the level of the patient's mouth, and the illumination must be brilliant.

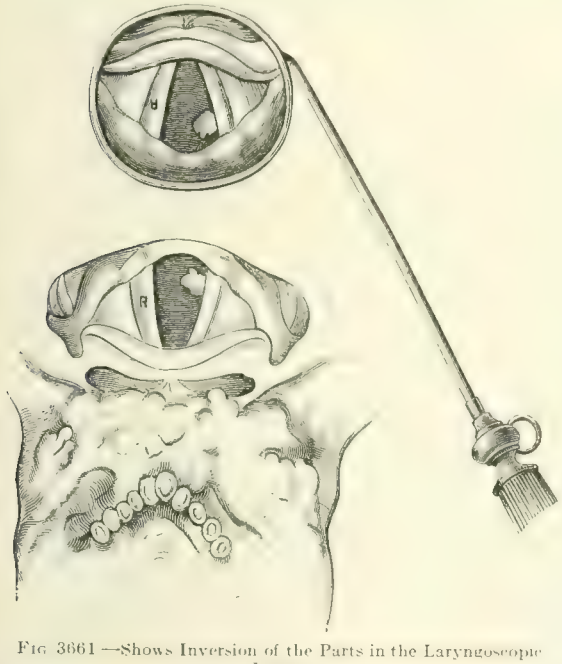

Fig. 3661.—Shows Inversion of the Parts in the Laryngoscopic Image.

Fig. 3662.—Reflected Image of the Larynx. (Farlow.)

As previously stated, one should be able to see the epiglottis before the patient says "ay." During phonation one should get a perfect glimpse of the inner portion of the epiglottis down to the tuberculum, should take note of the color and condition of the aryepiglottic fold, the false vocal cords, the upper surface of the arytenoid cartilages, of the fossa of Morgagni below the false cords, and of the whole length of the true vocal cords. One should judge of the tension and appearance of the cords as well as the character of the tone which the patient is taking. During the immediately following inspiration one should take note of the character of the motion imparted to the cords, whether it is alike in each cord, and of the promptness of this motion together with that of the retreating arytenoids as the movement apart takes place. A good view should be had of the interarytenoid space and the posterior wall of the larynx, as it is frequently here that pathological processes are present, and any swelling of the subcordal bands should be noted, whether the edge of the vocal cords are thickened or rounded, and last but not least, the character of the tracheal mucous membrane can be noted just as easily in many cases as any other part of the throat and much deduced from the knowledge thereby gleaned. On subsequent glances at the larynx one should be able to make out more exactly the position taken by the cords when placing the different tones, and in singers one often thereby discovers the effects of a bad method or the bad interpretation of a good method of singing.

During the process of making a laryngoscopic examination it is also the province of the examiner to take into consideration the condition of the rest of the hypopharynx. One can see the base of the tongue, the condition of the lingual tonsil, the shape, size, and condition of the back or lingual surface of the epiglottis, the outer side of the aryepiglottic folds, the sigmoid or pyriform fossæ, and during the taking of a high tone one can see down behind the arytenoids toward the upper part of the esophagus. Thus it is possible by the simple use of the indirect method to discover foreign bodies or pathological conditions which exist in these regions as well as to have made an examination

of the condition of the parts that are intrinsic to the larynx proper. HENRY L. SWAIN.

Laryngoscopy, Direct.—See *Bronchoscopy.*

Laryngoscopy, Suspension.—*Definition.*—Suspension laryngoscopy is the name given to the procedure of exposing the larynx for operation, by means of a hook-shaped instrument suspended from a gallows attached to the table, by which the recumbent patient is suspended upon his anterior pharyngeal wall. It is a modification of direct laryngoscopy (see vol. ii., p. 531, of this HANDBOOK).

History.—It was devised by Killian in 1910 and has since been developed by Killian, Kahler, Albrecht, and others.

Apparatus.—A special table which can be raised and lowered and which is especially constructed for the attachment of the suspensory mechanism is essential for the best results. The suspension apparatus proper consists of an upright having a horizontal extension at the top and called a gallows (Fig. 3663). The position of the gallows is adjustable like the slide rest of a lathe. A suspension hook hanging down from the gallows carries a tongue spatula for insertion in the pharynx. A counterpressure rod extends downward for pushing the larynx backward better to expose the anterior commissure.

Light is furnished either from a head mirror or a Kirstein headlamp (Fig. 1152, p. 532, vol. ii., of this HANDBOOK). All of the instruments devised for operating by direct laryngoscopy may be used in the suspension method.

FIG. 3663.—Table and Apparatus for Suspension Laryngoscopy. The Operator is holding in his right hand the suspension hook with tongue spatula attached ready for introduction.

FIG. 3664.—Suspension Apparatus in Position. The patient's head is suspended on the base of the tongue, not on the spring apparatus under the vertex. The curved rod pressing upon the front of the patient's neck is for counterpressure in bringing down the anterior commissure.

Anesthesia.—The procedure is usually done under general anesthesia, though great care is necessary in the anesthetizing of patients with laryngeal obstruction, because of the danger of respiratory arrest. Killian has recommended the "twilight sleep" induced by scopolamine, three decimilligrams, with 0.01 gram of morphine hypodermically for adults. Cocaine, scopolamine, and morphine are all very dangerous for use in children.

Technique.—The introduction of the instrument and the proper suspension of the patient on his anterior pharyngeal wall is not difficult for those familiar with direct laryngoscopy (see vol. ii., p. 531, of this HANDBOOK); but should never be attempted by anyone unfamiliar with ordinary direct laryngeal operating in the recumbent position. The patient being placed recumbent upon the table with the mouth directly under the gallows, and the anesthesia being carried to full relaxation, a tongue spatula suited to the size of the patient is attached to the suspension hook and is introduced posteriorly to the tongue until the spatular tip is in the glossoepiglottic fossa. The patient's head which has been supported by an assistant up to this point is now allowed to drop so that the weight of the head and neck hangs upon the spatular hook posteriorly to the tongue. The headlight or head mirror reveals the epiglottis hiding the larynx. The epiglottis lifter is now attached to the tongue spatula and pushed in place raising the epiglottis. The anterior commissure still does not come into view and must be pushed downward either with the finger of an assistant externally or with the counterpressure rod of the apparatus (Fig. 3664). Operating instruments such as forceps are now used for the removal of the growth or other procedure, the precaution being taken always to warm instruments before introduction.

CHEVALIER JACKSON.

Laryngostomy.—*Definition.*—Laryngostomy is the name given to the surgical procedure of laying open the larynx anteriorly and keeping it open for a long period of treatment, during which the larynx becomes lined with epidermal epithelium. More or less of the trachea is usually included in the opening and the procedure is then a laryngotracheostomy.

History.—It was first done for stenosis by Heryng in 1894. It has been elaborated and developed by Sargnon, Killian, Chevalier Jackson, and others.

Indications.—It is indicated in cicatricial stenosis of the larynx enabling the patient to abandon his tracheotomic cannula. With proper patience in the

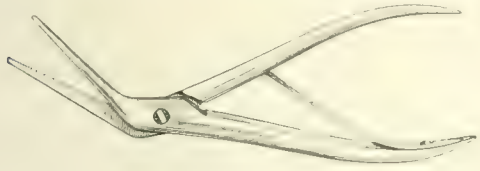

Fig. 3665.—Turbinotome of the Author, originally devised for turbinotomy but found excellent for thyrotomy and laryngotomy.

carrying out of the prolonged after-treatment it will cure every case in which there has not been too great a loss of laryngeal cartilage.

Contraindications.—Serious organic disease, pyrexia, active lues, and active tuberculosis are absolute contraindications. Bronchial and pulmonary disorders greatly increase the risk, and if irremediable they are contraindications.

Instruments, preparation of the patient, and position of the patient are the same as indicated in the article on Laryngofissure.

Anesthesia.—After sterilizing the skin with iodine solution in the usual way, a hypodermic syringe is used to inject between the layers of the skin normal salt solution containing about one-tenth of one per cent. of cocaine, the anesthetized line extending from the tracheotomic wound upward to the thyrohyoid membrane.

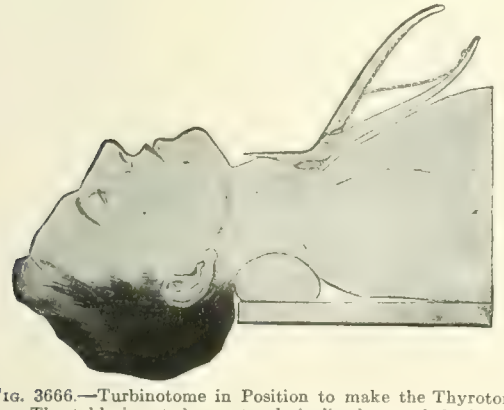

Fig. 3666.—Turbinotome in Position to make the Thyrotomic Clip. The table is not shown steeply inclined toward the head as it should be before the turbinotome is inserted.

Technique.—Without any preliminary incision of the skin the lower branch of the turbinotome (Fig. 3665) is inserted upward through the tracheotomic fistula until the end of the blade reaches the thyroid notch as noted by the external blade (Fig. 3666). All the tissues, including mucosa, cicatrices, cartilage, and skin are divided at one clip of the turbinotome. The wings of the thyroid cartilage are then spread with retractors, exposing the interior of the larynx. If there is much redundancy of tissue, or if cicatricial bands are present, these should be excised with curved scissors. The skin on each side should then be sutured down to the deeper tissues on the same side, but, in the author's opinion, preferably not to the cartilage lest the latter be damaged. The object is to cause a dipping down of the skin into the open trough-like wound. A soft rubber tube of sufficient size to fill the larynx and long enough to extend up to the top of the arytenoids is placed in the larynx. The laryngostomic cannula is inserted in the trachea,

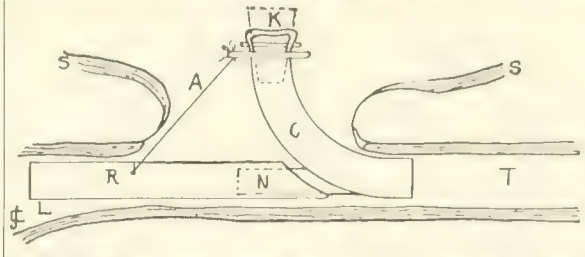

Fig. 3667.—Schema showing the Author's Apparatus for Laryngostomy. The hollow upward metallic branch (*N*) of the cannula (*C*) holds the rubber tube (*R*) back firmly against the spur which always exists on the back wall of the trachea in patients who have long worn a tracheotomic cannula. The air passing up through the rubber tube (*R*) permits the patient to talk in a loud whisper, the external orifice of the cannula being occluded most of the time with the cork (*K*). *L*, larynx; *T*, trachea.

and the soft rubber tubing is pulled down over the upward projecting branch of the cannula and tied to the latter with silk, which has been passed through the lower end of the rubber with a needle. A gauze dressing is then packed firmly into the trough over the rubber tubing and is held in place by a few turns of a bandage around the neck. If the patient breathes well through the mouth, which is usually the case, a cork is placed in the external opening of the laryngostomy cannula (Fig. 3667) permitting the patient to whisper.

Fig. 3668.—Lateral Radiographic View of the Author's Laryngostomy Apparatus (Fig. 3667) in Position in the Living Patient.

After-care.—The dressing should be changed every third hour and, for the first week, the gauze should be wrung out of bichloride of mercury solution 1:10,000 because of the constant presence of infectious

secretions. Later the granulations will protect and only sterile gauze is needed. Nurses familiar with laryngeal and tracheal work are necessary. The purpose of the rubber tubing is to cause a softening and "melting away" of the cicatricial tissue in the larynx. The sizes of the rubber tubes must be increased as fast as possible without causing sloughing. Once a week is about as short an interval as possible for increasing the size, the tube being taken out for cleaning and put back, at first every day, later every alternate day. When the tubing has reached the size of No. 40 (French), in the adult, no further increase is needed, but the apparatus must be continued with this size tube until the interior of the larynx is completely epidermatized. This may require six months or more. The success of the procedure depends altogether on this prolonged after treatment. After the interior of the larynx is epidermatized, the apparatus is removed, and if after six months no recurrence of the stenosis has demanded a repetition of the treatment, the fistula may be closed by a plastic operation, using skin flaps from the neck.

CHEVALIER JACKSON.

Laryngotomy. *See Tracheotomy.*

Larynx, Abscess of the.—Abscess of the larynx is a circumscribed collection of pus occurring in or bordering upon the larynx. It is liable in either situation to impede the breathway, even to the point of suffocation, and to meet this emergency, or rather to prevent it, by a timely incision of the abscess, involves an understanding in advance of the nature and exact location of the obstruction.

1. *Abscess Dependent upon Perichondritis.* Both acute and chronic suppuration dependent upon perichondritis with its various constitutional and local causes, prominent among which are syphilis, tuberculosis, and carcinoma, are considered at length under the title of *Perichondritis of the Larynx*, which is the complement of the present subject of *Abscess*.

2. *Intrinsic Abscess.*—Exclusive of those dependent upon perichondritis, abscesses which originate within the larynx itself are exceedingly rare. Yet one may occur as a terminal stage of certain severe forms of acute submucous laryngitis, although diffused phlegmonous suppuration and acute edema are the usual terminations, and when abscess occurs these conditions are likely to be associated with it.

3. *Abscess Bordering upon the Larynx.*—It is essential to consider in this connection the laryngeal phase of those suppurations which encroach upon the larynx from neighboring structures; as, from the root of the tongue in lingual phlegmon; the floor of the mouth in Ludwig's angina; the wall of the pharynx in retropharyngeal lymphadenitis; and the region of the tonsil in peritonsillar abscess. For, whether by compression or overriding of its lumen or by extension to it of edematous tumefaction, abscesses of this variety leading to obstruction of the larynx are more numerous and result in more fatalities than any other class.

ETIOLOGY.—While any attack of laryngitis, the result of exposure leading to infection by ordinary pyogenic cocci, may possibly eventuate in abscess, it is probable that the particular strains responsible for so-called phlegmonous inflammation, whether terminating in circumscribed or diffused suppuration, possess unusually virulent qualities. The fact that an undue proportion of laryngeal complications, including abscess, were observed during the recent epidemics of infection of the throat by the *Streptococcus hemolyticus* points to it as one of the strains, while the similarity and occasional conjunction of acute phlegmonous laryngitis with recognized erysipelas point to the streptococcus of erysipelas as another one of the strains responsible. Also, either with or without initial perichondritis, abscess may occur as a serious complication of typhoid fever, typhus fever, septicemia, ulcerative endocarditis, erysipelas, smallpox, scarlet fever, and measles. It is liable to follow contusions and fractures of the cartilages due to external injury.

PATHOLOGICAL ANATOMY.—Instead of encroaching upon the larynx from the lingual base an abscess may originate on the lingual surface of the epiglottis and extend to the vallecula, in one of which it may rupture. It does not extend over the free edge of the epiglottis to the laryngeal surface. It may point externally at the side of the neck.

SYMPTOMS.—Apart from the symptoms of simple laryngitis a submucous inflammation leading to abscess soon manifests itself by dyspnea, by tenderness to pressure and severe pain on swallowing and speaking. But if the abscess be on the lingual surface of the epiglottis there may be no dyspnea, only very painful dysphagia; if on the aryepiglottic fold the dyspnea may be only inspiratory. The dyspnea of retropharyngeal abscess, pressing upon the larynx, is suspended by the dorsal and head-downward positions.

DIAGNOSIS.—The differentiation from other obstructive conditions of the larynx and the exact location of an abscess, being based largely upon the laryngeal image, can be better determined early than late, that is, before serious dyspnea has set in, for when a patient is already struggling for breath the mere insertion of a throat mirror, tongue depressor, or finger momentarily intensifies his struggle for air. The yellowish point of an abscess is less translucent than simple edema and unlike the dusky red of diffused phlegmonous inflammation when without edema. In subglottic laryngitis the swelling is bilateral and symmetrical. Actual fluctuation is not often discernible, but a certain elasticity may usually be elicited by finger or probe. Severe pain indicates an abscess, but perichondritis should also be remembered in this connection. In doubtful cases an exploratory puncture with a laryngeal lancet is justified.

PROGNOSIS.—In all the thirteen cases of intrinsic abscess observed by Mackenzie, the symptoms were very severe, but all terminated in recovery; in nine the abscess was opened, and in four it burst spontaneously. Nevertheless, without surgical interference—either evacuation of the abscess or when necessary a prompt tracheotomy—the prognosis would be grave.

TREATMENT.—While the disease is still in the stage of *laryngitis submucosa acuta*, appropriate measures to prevent the possible formation of an abscess are absolute rest for the voice and cold applications. Cold wet cloths frequently reapplied may be used externally, and cracked ice may be dissolved in the mouth. Cold applications, however, should not be indefinitely prolonged. When suppuration is obviously imminent hot applications are more comforting. If edema is a marked feature scarification is usually recommended, but the benefit is slight. A one per cent. cocaine solution with adrenalin 1:10,000 in normal salt solution sprayed downward, affords temporary relief to dyspnea by causing the edematous tissue to shrink. The atmosphere should be kept moist. The abscess when formed should be opened under laryngoscopic observation by means of a laryngeal lancet. Surgical intervention, be it by incision of the abscess or by tracheotomy, should not be too long deferred, as the dyspnea is liable to culminate suddenly in the moribund state, which leaves one without recourse other than tracheotomy, and without much hope from it; the author's experience with adult patients has been that, when the asphyxia has already

advanced to the moribund stage though most of them, after tracheotomy, were restored to consciousness, they all succumbed within a few hours afterward to the secondary congestion of the lungs which follows so advanced a degree of asphyxia. In marked contrast, however, was the effectiveness of treatment when opportunity offered at an earlier stage. The best example among others was an abscess so deeply situated and firmly inclosed by fascia in the root of the tongue bordering the larynx, that spontaneous evacuation in time to prevent the dyspnea from culminating in asphyxia could not have been expected; whereas, while still tolerant of laryngoscopic procedure, on the third exploratory puncture at a depth of three centimeters pus in quantity was reached and recovery promptly ensued. If there is pronounced dyspnea and evacuation of the abscess is not feasible, the only efficient resource is tracheotomy performed under local infiltration anesthesia. Intubation is not a satisfactory substitute for tracheotomy in these cases. W. E. Casselberry.

Larynx, Anatomy of the—The larynx, which is the principal organ of phonation as well as the guardian against the entrance of foreign bodies into the trachea and bronchial tubes, is situated at the upper and fore part of the neck. Until puberty it is small and presents a rounded form in front. At about this time in the male there are marked and rapid changes. It becomes nearly double in size and the thyroid cartilage produces a prominent ridge in front, called the Adam's apple.

The larynx lies between the base of the tongue and the hyoid bone above and the beginning of the trachea below, and, when at rest, in the adult, is in front of the fourth, fifth, and sixth cervical vertebræ, from which it is separated by the lower portion of the pharynx and the prevertebral muscles. In front, it is covered near the median line by the skin and cervical fascia. On either side there are also the sternohyoid, the sternothyroid, and the thyrohyoid muscles with the upper portion of the lateral lobe of the thyroid gland and a portion of the inferior pharyngeal constrictor. Farther back and on the side are the large cervical vessels. At the upper part the larynx is triangular in shape with the apex pointing at the anterior median line, but it approaches the shape of a cylinder and is much smaller below, where it joins the trachea. The hyoid bone, the thyroid and cricoid cartilages, the thyrohyoid membrane, and the cricothyroid membrane are easily located and are important landmarks.

The Interior of the Larynx.—The first portion of the larynx we see when looking from above is the epiglottis situated at the base of the tongue. This varies greatly in shape, size, and position. Its crest may present itself as the arc of a small or a comparatively large circle. It is usually situated in the median line, and is commonly but not always symmetrical; it swings up and down over the superior aperture of the larynx, so that it may be found in any position from the vertical to the horizontal. Immediately below the crest of the epiglottis is a rounded prominence, the cushion produced by a prominence of the petiolus together with some fatty and adenoid tissue. The mucous membrane covering the epiglottis is of a yellowish-pink color and is more adherent to the posterior surface, in which open the mouths of a number of glands. From both sides of the epiglottis there extend toward the arytenoids, at the posterior portion of the larynx, two folds of mucous membrane, the arytenoepiglottidean folds, which contain some ligaments and muscular fibers as well as the cuneiform cartilages. These cartilages show as a whitish nodule in front of the prominence produced by the arytenoid and Santorini's cartilages on either side. At the posterior portion of the larynx is a space called the interarytenoid space. This is between the arytenoid cartilages, quite extensive during respiration but much shorter during phonation. Just below the apex of the arytenoids and extending from the front of these to the angle of the thyroid cartilage, below the attachment of the epiglottis, are two folds of mucous membrane enclosing delicate fibrous bands, the superior thyroarytenoid ligaments. These folds are called the ventricular bands and form the upper boundary of a space, the ventricle of the larynx, which extends under and between them and the ala of the thyroid cartilage, and then terminates anteriorly in a pouch, the sacculus laryngis. This pouch contains many mucous glands which by their secretion moisten the vocal cords. Just below and parallel with the ventricular bands are two white bands, the *true vocal cords*. They appear to be a part of the ventricular bands, but are at a lower level and are separated from them by the ventricles. They are composed of yellow fibrous tissue covered by a very thin and closely adherent mucous membrane. A cross-section shows the vocal cord to be a triangular prism with the base outward and attached throughout its whole extent to fibers of the thyroarytenoid muscle. Anteriorly the cord is attached to the receding angle of the thyroid cartilage just below the ventricular band and within the insertion of the thyroarytenoid muscle. Posteriorly there are three sets of fibers; one is attached to the vocal process of the arytenoid cartilage, another to its anterior surface, and the third to the cricoarytenoid capsular ligament. At their posterior attachment there is often seen a slight depression of a pearly white color; this is the tip of the vocal process of the arytenoid cartilage. There is an open triangular space between the vocal cords—the *glottis* or *rima glottidis*. This varies in extent according to sex and age, being about seven-eighths of an inch long in the adult male

Fig. 3669.—Frontal Section of an Undissected Larynx. The three divisions of the larynx are marked off by the straight dotted lines on the right side of the figure. *A*, The superior compartment, extending from the aryepiglottic folds to the superior vocal cords (ventricular bands); *B*, the cavity of the ventricle, bounded above by the superior vocal cord, below by the inferior or true vocal cord, and externally by the elastic membrane of the larynx; *C*, the inferior or subglottic compartment, extending from the true vocal cord to the inferior border of the cricoid cartilage; 1, edge of the superior vocal cord; 2, edge of the inferior vocal cord. Below the true vocal cord is seen the *thyroarytenoideus* muscle.

and about five-eighths of an inch in the female. The width constantly varies as the cords are approximated or separated, and in the male is about one-half inch at the posterior portion when the cords are separated to their fullest extent. Through the glottis can be seen the anterior portion of the cricoid and a few of the superior rings of the trachea and at times the whole anterior portion of the trachea as far down as the bifurcation. Below the glottis the space widens and is oval laterally, but gradually approaches a circular form as it extends toward the trachea.

Cartilages of the Larynx.—There are five principal cartilages of the larynx, the epiglottis, the thyroid, the cricoid, and the two arytenoid, and two pairs of very small unimportant cartilages, the cornicula laryngis (cartilages of Santorini) and the cuneiform cartilages (cartilages of Wrisberg). The thyroid, the cricoid, and the two arytenoid cartilages are of hyaline cartilage and liable to become ossified with age, while the epiglottis and the four small cartilages are of a fibrous nature.

The thyroid cartilage, the largest in the larynx, consists of two large quadrilateral symmetrical plates called alæ, which unite anteriorly at an angle of 85° to 95° and form the greater portion of the front and sides of the larynx.

Fig. 3670.—Anterior View of the Cartilages of the Larynx. 1, Upper rings of the trachea; 2, anterior arch of the cricoid; 3, anterior portion of the cricothyroid membrane (conoid ligament); 4, 4, lateral halves or alæ of the thyroid; 5, median portion of the thyroid; 6, epiglottis; 7, thyroepiglottic ligament. (Luschka.)

The alæ present an external flattened surface, marked by a rather indistinct oblique line, running from the inferior tubercle at the lower anterior border upward, outward, and backward to the superior tubercle at the posterior part of the superior border. This ridge gives attachment below to the sternothyroid, and above to the thyrohyoid muscle, and just below this line are attached a part of the inferior constrictor of the pharynx and the stylopharyngeus. The internal surfaces are more or less concave and smooth, and near the angle of union in front are attached the epiglottis, the thyroepiglottidean and thyroarytenoid muscles, and the true and false vocal cords. Of the borders, the anterior is the shortest, and, except for a bursa which is sometimes present, is subcutaneous. The upper is somewhat convex except for a well-marked concavity near the superior cornu. The posterior extends above into a long delicate process, the superior cornu, which gives attachment at its extremity to the thyrohyoid ligament, and terminates below in a short and thick process, the inferior cornu, presenting on the inner side a small oval facet which articulates with the side of the body of the cricoid. The

Fig. 3671. Posterior View of the Cartilages of the Larynx. 1, Broad posterior arch of the cricoid; 2, internal surface of the ala of the thyroid; 3, arytenoid cartilage; 4, corniculum laryngis (cartilage of Santorini); 5, the posterior surface of the epiglottis. (Luschka.)

lower border is nearly straight and is notched near the inferior cornu. It gives attachment anteriorly to the cricothyroid membrane and laterally to the cricothyroid muscle.

The cricoid cartilage, much thicker and stronger than the thyroid cartilage, forms the lower and greater part of the posterior portion of the larynx. The anterior portion is rounded and convex in shape and measures vertically about one-fifth of an inch. The external surface at the front and sides is smooth and gives attachment to the cricothyroid muscles and inferior pharyngeal constrictors. Posteriorly, it rises until its vertical diameter is about three times that of the anterior portion. It also increases in thickness and forms the signet portion of the ring. This shows a depression near the middle on the superior border, on either side of which, looking upward and outward, is an elongated, oval and slightly convex facet for articulation with the arytenoid cartilages. At the middle of the posterior surface is a slight vertical ridge to which are attached a few of the longitudinal fibers of the esophagus.

Fig. 3672.—Posterior View of the Cricoid and Arytenoid Cartilages, showing the Attachment of the Arytenoideus Muscle. 1, Cricoid; 2, arytenoid; 3, corniculum laryngis; 4, arytenoideus muscle. (Luschka.)

On either side of this are depressions which are occupied by the posterior cricoarytenoid muscle; and just outside of these are the slightly raised oval facets for articulation with the inferior cornua of the thyroid cartilage. The whole interior surface is smooth and covered with mucous membrane.

The arytenoid cartilages, two in number, are situated at the posterior superior portion of the larynx, and are the most active of all the cartilages in tuning the larynx

for the production of sound. To them are attached the vocal cords and all of the muscles controlling their movements except the cricothyroid. In shape they are three-sided pyramids and are about half an inch high and one-fourth of an inch wide. They articulate near the outer portion of the base with the facets on the superior surface of the cricoid, and their inner surfaces are nearly parallel. At each apex is situated the cartilage of Santorini. The inner surface, which is the narrowest of the three, is triangular in shape and nearly flat. It is covered with mucous membrane. The anterior surface has a triangular ridge at the junction of the lower and middle thirds, above and below which are concavities. Near the inner end of this ridge is attached the ventricular band. The thyroarytenoid muscle is attached to the rest of the surface. The posterior surface is triangular,

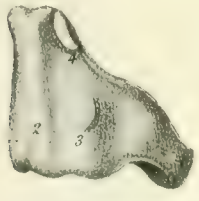

Fig. 3673.—Lateral View (right side) of the Cricoid Cartilage. 3, Articular surface for the inferior cornu of the thyroid; 4, articular surface for the base of the arytenoid. (Luschka.)

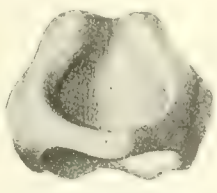

Fig. 3674.—Anterior View of the Cricoid Cartilage. 1, The anterior arch; 2, the posterior arch. (From Luschka.)

broad, and concave from above downward and gives attachment to part of the arytenoid muscle. The whole base is slightly concave, with a smooth, more marked concavity near the outer portion for articulation with the cricoid cartilage. The anterior angle extends into a horizontal process (the vocal process), to which the vocal cord of that side is attached. The external angle, which extends outward and backward, forms a short and rounded process (the muscular process), to which are attached the posterior and lateral cricoarytenoid muscles.

The epiglottis is a thin leaf-like cartilage which is attached to the inside of the thyroid cartilage just below the superior median notch. It is inside of, and attached to, the body of the hyoid bone. During respiration it is nearly vertical, but during deglutition as the larynx is drawn upward it drops backward and more or less completely closes the laryngeal opening. The anterior surface is covered by mucous membrane which is reflected on to the sides and base of the tongue, forming the lateral and median glossoepiglottidean ligaments. The posterior surface is concave from side to side and convex from above downward. There are numerous small pits, sometimes perforating the cartilage, which lodge small glands. The mucous membrane is smooth and at the sides forms the arytenoepiglottidean folds.

The *cartilages of Santorini*, two small conical nodules of fibrocartilage, articulate with the tip of the arytenoid cartilages and are sometimes firmly united to them. The arytenoepiglottidean folds are attached to these cartilages and enclose the *cartilages of Wrisberg* at a short distance in front of this attachment. These latter cartilages give rise to the elevations which are plainly seen in the laryngeal image.

Ligaments.—The cartilages of the larynx are bound together and to the hyoid bone above and the trachea below by fibrous bands and membranes. The thyroid cartilage is attached to the hyoid bone by a broad central membrane and two lateral rounded ligaments. The thyrohyoid ligament is a broad fibrous and slightly elastic membrane, thick in the middle where it is subcutaneous, and thin and loose at the sides where it is pierced by the superior laryngeal vessels and nerve. It is attached below to the whole upper edge of the thyroid cartilage, and above it passes behind the posterior surface of the hyoid bone, being separated from it by a synovial bursa, to be attached to its surface. This allows the larynx to be drawn upward within the hyoid bone. The lateral thyrohyoid ligaments are two rounded elastic cords just back of the middle ligament. They connect the superior cornua of the thyroid cartilage with the extremities of the great cornua of the hyoid bone.

The epiglottis is connected with the receding angle of the thyroid cartilage by a long rounded bundle of fibroelastic tissue, the thyroepiglottic ligament. It is also attached to the hyoid bone by a fibroelastic membrane extending from near the apex of its anterior

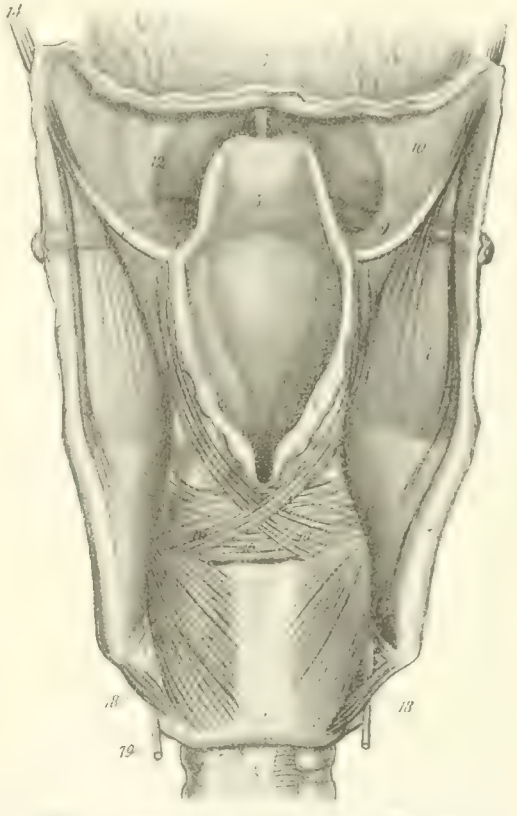

Fig. 3675.—Posterior View of the Larynx. The pharynx and mucous membrane are removed. 1, Trachea; 2, posterior cricotracheal ligament; 3, cricoid; 4, posterior border of the thyroid; 5, epiglottis; 6, great cornu of the hyoid bone; 7, root of the tongue; 8, thyrohyoid; 9, hyoepiglottic membrane; 10, hyoglossal membrane; 11, middle glossoepiglottic ligament; 12, lateral glossoepiglottic ligament; 13, pharyngoepiglottic fold; 14, stylolaryngeus muscle; 15, arytenoideus muscle; 16, 16, crossing bundles of the arytenoepiglottideus (*constrictor vestibuli laryngis*); 17, posterior cricoarytenoideus muscle; 18, 18, a few slender bundles, cricothyroideus posticus, or keratocricoideus of Merkel; 19, inferior laryngeal nerve. The aryepiglottic folds are seen reaching from the sides of the epiglottis to the arytenoid eminences, and bounding the superior orifice of the larynx, the *vestibulum laryngis*. (Luschka.)

surface to the upper surface of the body of the hyoid bone. There are two lateral folds and one median fold of mucous membrane, already mentioned, which attach the epiglottis to the base of the tongue.

The cricothyroid membrane and two capsular ligaments bind the thyroid and cricoid cartilages together. The cricothyroid membrane, triangular in shape, is thick in front where it joins the cricoid and thyroid cartilages, and thin at either side where it

extends from the cricoid cartilage to the inferior margin of the true vocal cords, and is joined with them at their anterior insertion into the thyroid cartilage. Anteriorly the cricothyroid membrane is subcutaneous and is crossed horizontally by a small arterial branch which forms an anastomosis between the cricothyroid arteries of either side. At the sides the cricothyroid membrane is covered by the cricothyroid and cricoarytenoid muscles. The capsular ligaments are lined with synovial membrane, and bind

Fig. 3676.—Right Lateral View of a Dissected Larynx. The ala of the thyroid is removed. 1, Cricoid; 2, thyroid; 3, arytenoid; 4, epiglottis; 5, hyoid bone; 6, posterior cricoarytenoid muscle; 7, arytenoepiglottideus muscle; 8, the lateral cricoarytenoideus; 9, thyroarytenoideus. The other fibers, seen running in various directions, are inconstant in their distribution. (After Luschka.)

the articulations of the inferior cornua of the thyroid with the sides of the cricoid cartilage. A loose capsular ligament lined with synovial membrane and strengthened posteriorly by a strong band, the posterior cricoarytenoid ligament, connects the arytenoids with the cricoid cartilage.

Muscles. The larynx as a whole is moved and also fixed in its varying positions by muscles which attach it to the hyoid bone above, the sternum below, and the region of the fourth and fifth cervical vertebræ behind. It is elevated principally by the thyrohyoid muscle and depressed by the sternothyroid; and the two muscles, acting at the same time, tend to hold it firmly in a fixed position.

There are also some muscular fibers, forming the so-called laryngopharyngeal muscles which are attached to the posterior border of the thyroid cartilage and pass backward around the pharynx to be inserted into the vertebræ behind. The sternohyoid, the omohyoid, the two lower constrictors of the pharynx, the stylopharyngeus, and the palatopharyngeus also act more or less upon the larynx as a whole. The thyrohyoid is a small quadrilateral muscle arising from the lower border of the body and greater cornu of the hyoid bone and is inserted into the oblique line on the ala of the thyroid cartilage; and the sternothyroid has its upper attachment to this same oblique line and is attached below to the posterior surface of the manubrial portion of the sternum, below the attachment of the sternohyoid. The middle thyroid vein is situated along its inner border.

The muscles which change the shape of the larynx and act directly upon the vocal cords are the cricothyroid the cricoarytenoideus posticus, the arytenoideus lateralis, the arytenoideus, and the thyroarytenoideus.

The cricothyroid, a short triangular muscle, is attached below to the anterior and lateral portion of the cricoid cartilage. From this the fibers pass upward and outward and divide into two bundles, the anterior being attached to the inner lower margin of the thyroid cartilage and the posterior to the anterior border of the lower cornu. Whether this muscle depresses the thyroid or elevates the cricoid it increases the length and tension of the vocal cords. The posterior cricoarytenoid muscle is attached to the muscular process of the arytenoid cartilage behind that of the lateral cricoarytenoid. The fibers spread like a fan, the upper nearly horizontal and the lower nearly vertical, and are attached to the broad depression on the posterior surface of the cricoid cartilage. This muscle draws the muscular process of the arytenoid backward and inward, and thus by rotating the vocal processes outward widens the rima glottidis. The lateral cricoarytenoid, from its attachment to the muscular process and adjacent part of the anterior surface of the arytenoid cartilage, spreads out and passes downward and forward to be attached to the upper slanting surface of the cricoid cartilage as far back as the articulation of the arytenoid. The action of this muscle is to draw the muscular process of the arytenoid forward and downward and, by rotating the vocal process inward, to approximate the vocal cords. The action of this muscle is antagonistic to that of the posterior cricoarytenoid, and when the two act simultaneously the arytenoid is not rotated but is drawn inward and the glottis is narrowed.

The arytenoideus is a single muscle which passes between the posterior outer borders of the arytenoid

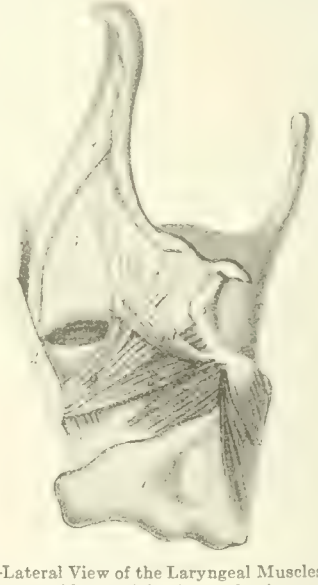

Fig. 3677.—Lateral View of the Laryngeal Muscles. 1, Cricoid; 2, thyroid; 3, arytenoid; 4, epiglottis; 5, elastic membrane of the larynx; 6, posterior cricoidarytenoid; 7, lateral cricoarytenoid; 8, thyroarytenoid; 9, thyroepiglottideus; 10, fine fibers spreading out in the elastic membrane (*arymembranosus*). (Luschka.)

cartilages. The deep fibers are transverse but the superficial pass obliquely from the base of one to the apex of the other arytenoid. Some of these fibers pass around the cartilages and join with the fibers of the thyroarytenoid or the arytenoepiglottic muscle. The arytenoideus draws the bases of the arytenoid cartilages together.

The thyroarytenoid muscle contains both longitudinal and transverse fibers and is made up of internal and external portions which are sometimes

described as two distinct muscles. The long fibers of the inner portion arise in front from the receding angle of the thyroid cartilage, a few sometimes from a nodule of fibrous tissue in the anterior portion of the cord, the cartilage of Luschka. They pass backward with a slight outward curve and are attached to the whole length of the vocal process and adjacent outer surface of the arytenoid. The whole inner border is attached to the vocal cord. The outer portion arises from the thyroid cartilage near that of the inner, and also from the cricothyroid membrane. Some of the fibers pass backward and are inserted into the lateral border and muscular process of the arytenoid cartilage, others pass obliquely upward to the arytenoepiglottidean fold, and still others pass vertically in a thin layer around the ventricle and sacculus, ending in the

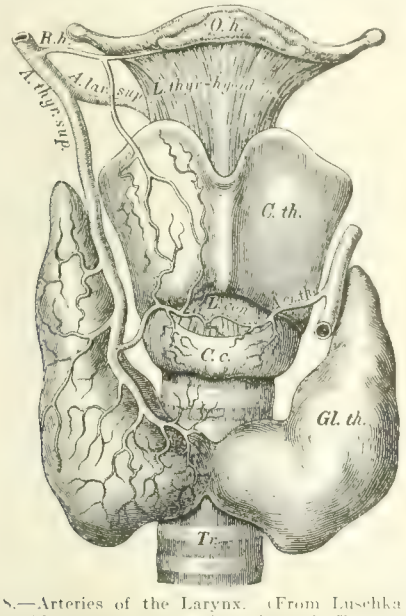

FIG. 3678.—Arteries of the Larynx. (From Luschka.) *C. th.* Thyroid cartilage; *Gl. th.*, thyroid gland; *Tr.*, trachea.

false cord. There is one set of fibers which pass from the anterior attachment outward around the sacculus laryngis and are inserted into the side of the epiglottis. On account of the various directions and attachments of this muscle its action is rather complicated. The longitudinal fibers of the inner portion tend to bring the edges of the vocal cords together, while the short oblique fibers tend to tighten them.

The Blood Supply.—The superior thyroid artery gives off a branch, the superior laryngeal, which passes with the superior laryngeal nerve between the great cornu of the hyoid bone and the thyroid cartilage through the thyrohyoid membrane, and supplies the structures of the anterior superior portion of the larynx. The inferior laryngeal artery also arises from the superior thyroid, near the lower border of the thyroid cartilage. It divides into two branches, one anastomosing with its fellow of the other side and the other with branches of the superior laryngeal. The posterior laryngeal artery, a branch of the inferior thyroid, passes with the recurrent laryngeal nerve; it then divides, near the cricoarytenoid articulation, into two branches which anastomose with branches of the superior laryngeal artery.

The laryngeal veins are associated with the arteries and empty into the internal jugular through the superior, middle, and inferior thyroid.

Lymphatics.—The lymphatics may be divided into two sets. The upper pierce the thyrohyoid membrane and empty into the glands located near the bifurcation of the common carotid artery. The lower, after piercing the cricothyroid membrane, end in glands in front of this membrane or at the side of the cricoid cartilage.

Nerves. The pneumogastric nerves, joined by sympathetic fibers, give off the superior laryngeal nerves, which supply the mucous membrane, the cricothyroid muscles, and a part of the arytenoideus muscle, and the inferior laryngeal nerves which supply all of the other muscles of the larynx.

EDGAR M. HOLMES.

Larynx, Burns and Scalds of the. Severe acute inflammation of the larynx, involving the submucous areolar tissue, may follow the swallowing of very hot liquids and of corrosive poisons, the inhalation of flame or of highly heated air, or the impaction of a foreign body.

The pathological condition commonly met with in the three accidents above named is, practically, acute laryngeal edema. The early symptoms are pain, dyspnea, dysphagia, aphonia, and shock. Respiration is rapid and stridulous, the face pale and anxious, and the patient very restless. The symptoms may be mild at first but later they are severe, especially after the ingestion of caustic liquids. Often edema of the larynx and fatal dyspnea rapidly come on, or serious pulmonary complications quickly follow.

Mild cases may end in recovery in a few days. Death is apt to occur in from one to two days from dyspnea or shock, or later from laryngitis, bronchitis, or pneumonia. The inhalation of flame or of steam is always a very serious complication of the other injuries commonly present owing to the general depression and the mental shock which are likely to accompany such cases. Treatment should be at once instituted. Absolute quiet should be secured, digestion regulated, strength supported, and the patient carefully watched for the development of laryngeal and pulmonary symptoms. Many writers recommend the administration of a dose of calomel at the outset.

The sucking of cracked ice, the administration of a non-depressant emetic, and thorough scarification of the edematous tissue, as described in the preceding article, have been highly recommended. Applications of cocaine must be used with great caution, if at all, on account of the depressing effect of this drug upon the heart. The local application of the extract of the suprarenal glands to the affected region is often valuable. Of course, in case of the impaction of a foreign body the offending object must be removed. Too much stress cannot be laid upon the necessity for energetic treatment, and when the symptoms are urgent, immediate recourse should be had to tracheotomy, or, better still, to intubation of the larynx after the method of O'Dywer (see *Intubation*).

Laryngitis from corrosive poisoning is frequently followed by extensive sloughing, and eventually by cicatricial contraction which may require more or less important surgical treatment for its relief. (See *Larynx, Stenosis of the.*) D. BRYSON DELAVAN.

Larynx, Congenital Malformations of the.—Congenital malformations of the larynx may be classed under four heads, namely: (1) Absence; (2) excessive development; (3) cleft; and (4) deviations of form and situation.

Complete absence of the larynx occurs in the rare cases of monsters in which the head and the thorax are wanting, and which are known as acephali, amorphi, and acardiaci. A complete absence of the larynx has also been noted in a monster described as "inclusio fetalis peritonei."

Partial absence may consist either in a general atrophy of the organ, or in the absence of one or more of the cartilages. Thus, in some instances there

is a complete absence of the epiglottis; in others it is represented by a high rudimentary ridge; while in one case it is described as merely a fold of the mucous membrane. The thyroid, cricoid, and arytenoid cartilages may be absent. They also may be rudimentarily developed, either altogether as regards one of them, or only in certain parts of each. For instance, the thyroid may lack one or both superior cornua. Again, the thyroid may be cleft, and the two plates may be connected together by a cartilaginous band. The same abnormality has been observed in the cricoid, in some instances to such an extent that the connecting band may take the place of the original cricoid, and thus cause it to resemble a tracheal cartilage. Finally, the whole larynx may be abnormally small, as seen in the male when there is congenital atrophy of the testicle, or when castration has been practised early in life. In such cases it resembles the larynx of the female or of a child.

Hypertrophy.—This division may be made to include the double formation of the larynx observed in the case of double monsters, namely, in the so-called thoracodidymis and also in the dihypogastricus varieties. These possess two larynges, but only one pharynx and one esophagus. A cartilaginous plate is sometimes found interposed anteriorly between the wings of the thyroid.

Supernumerary cartilages are occasionally found on the outer corner of the cricoid cartilage. They are analogous to sesamoid bones. Supernumerary folds of the mucous membranes are sometimes seen, as, for instance, a transverse fold below the epiglottis.

The laryngeal ventricle may be abnormally wide and deep, and thus render the part more liable to eversion, to the lodgment of a foreign body, or to other accident. The anterior section of the glottic space may be more or less occluded by a web-like formation, of considerable density, and somewhat resembling an imperforate hymen.

Cleft Formation.—There is no such thing, it is said, as a congenital laryngeal fistula of the neck. A case of cleft epiglottis has been reported by Thomas R. French.

Congenital deviations of form and situation of the larynx are rare, and occur only in connection with congenital malformations of the most marked type, such as hemicephalus, and double spina bifida of the upper portion of the spine, and in extreme lordosis of the cervical vertebræ. In these the whole larynx is depressed and moved backward to the level of the upper dorsal vertebræ. The thyroid is placed very obliquely, by which the inferior diameter of the larynx is markedly increased, while the cricoid is situated much deeper, in proportion to the thyroid, and thereby the true and the false vocal cords are abnormally lengthened. The sinus pyriformis on each side is obliterated.

Slight asymmetry of the larynx, as to position and form, is not infrequently met with.

D. Bryson Delavan.

Larynx, Cricoarytenoid Disease.—Definition.—Arthritis of the cricoarytenoid articulation is an inflammation of the joint, usually involving the perichondrium and adjoining tissues. Ankylosis is a partial or complete immobility of the joint from the formation of adhesions and the organization of an inflammatory exudate, usually in consequence of a previous arthritis.

Etiology.—The most frequent cause is perichondritis, the various types of which are described under that name. Quite rarely, "cold" and vocal abuse influence infection. It may be due, in either the acute or the chronic form, to the focal suppurations responsible for so-called rheumatism, to gout, and the condition termed arthritis deformans. It is liable to follow either internal or external traumatism. It may be due to metastasis of the specific infecting organism in typhoid and other fevers, conjoined usually with secondary pyogenic infection, and it may arise by continuity of tissue in phlegmonous laryngitis and diphtheria. The cricoarytenoid joint may become stiff or even ankylosed from prolonged immobility in vocal-cord paralysis. The most frequent of all causes, however, is perichondritis due to syphilis, tuberculosis, or carcinoma.

Pathology.—In the milder forms of acute arthritis ascribed to "cold," vocal abuse, and laryngitis submucosa, and more particularly in the co-called rheumatic types, the serous exudation usually proceeds to resolution and absorption without suppuration, although more or less ankylosis is liable to result, presumably from the formation of adhesions. The *Spirochæta pallida*, leading to the infiltration of syphilis, may attack directly the cartilages and perichondrium, and tuberculous arthritis analogous to the white swellings of the larger joints is a possibility; but usually in these types, as well as in typhoid fever and septic cases, a secondary infection by pyococci occurs through ulceration of the soft parts, and this results in an abscess, necrosis, and exfoliation. Edema, which is a prominent feature of the acute stage, is replaced in the chronic state by a cellular infiltration leading to tumefaction of the overlying parts.

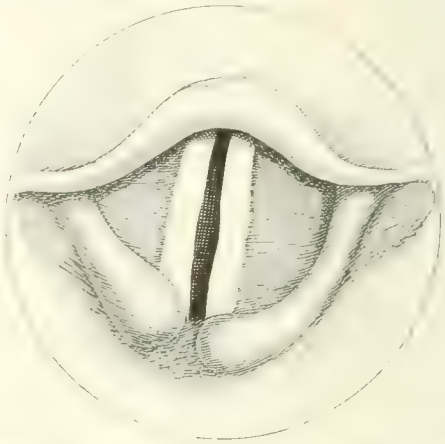

Fig. 3679.—Ankylosis of Right Cricoarytenoid Articulation. (Author's Case.)

Symptoms.—Acute arthritis will occasion febrile symptoms, hoarseness, and local discomfort. Swallowing is painful, and if there is much edema or swelling respiration may be seriously obstructed. Chronic ankylosis may be manifested only by impairment of the voice, although if it is double the dyspnea is liable to be serious, especially during acute exacerbations. The writer has recorded a case of this sort under the name of "arthritis deformans of the larynx," the typical deformities of that disease having been present in other joints of the body.

Laryngeal Image.—The vocal cord is more often fixed in the cadaveric position, as shown in Fig. 3119, which shows a typical case of unknown but probably syphilitic origin observed before the Wassermann test. On phonation the opposite movable cord will make a supplementary excursion across the median line to meet the fixed cord, producing an oblique distortion of the larynx which, however, in less degree is often seen in the absence of ankylosis and without any disability of the organ. On deep inspiration the fixed cord fails to abduct. The voice is weak and hoarse although not necessarily lost. Next in order, the cord is found fixed in or near the median line, when the voice will be

but little altered; and quite rarely the cord retains the position of abduction, when the voice is reduced to a whisper. If both sides are involved the cords are not usually symmetrically placed, but if both are near the median line there is serious dyspnea; if they are not near the median line, there is aphonia. Luxation or displacement of the arytenoid and absence of this cartilage in consequence of previous exfoliation distort the image in a corresponding manner.

Diagnosis.—The salient feature in diagnosis is to differentiate ankylosis of the cricoarytenoid joint from paralysis of the vocal cord. Usually in ankylosis there is either acute or remaining chronic tumefaction about the joint, while in paralysis there is none, unless one examines the case of paralysis at a time when the larynx is inflamed from "cold" or efforts to force the voice. In ankylosis without paralysis there is no "falling in" of the affected arytenoid, the sound arytenoid approaching it on phonation but not crossing or displacing it. In ankylosis there is nearly always a slight adductor movement; in complete recurrent paralysis there is none. A history of previous arthritis or its causes, especially typhoid fever or syphilis, is significant, but the diagnosis requires, further, a careful exclusion of any central or peripheral cause of paralysis, such as syphilitic bulbar disease, tabes, aneurysm, carcinoma of the esophagus or other neoplasms, goiter, toxic neuritis, etc.

Prognosis.—In acute arthritis the danger to life from dyspnea may require a prompt tracheotomy. In typhoid-fever cases the mortality is very high. The prognosis is favorable in traumatic, rheumatic, and syphilitic cases, but there is a liability to ankylosis.

Treatment.—In rheumatic and syphilitic arthritis and in cases of doubtful origin the patient should receive the specific medication which is appropriate to the constitutional disease. Cold applications externally are useful in the very early stage of acute arthritis. Alkaline and emollient sprays serve to clear the throat of mucus. Cocaine one per cent. with adrenalin 1:10,000 in normal salt solution causes temporary retraction of the edematous swelling, but its powers are limited. Chronic ankylosis is not amenable to treatment unless there is stenosis of the larynx, when forcible or gradual dilatation by intubation tubes and bougies or the operation of laryngofissure, perhaps including removal of obstructing cartilage, may be indicated.

W. E. Casselberry.

Larynx, Edema of the.—See under *Laryngitis*, p. 810.

Larynx, Erysipelas of the.—Erysipelas of the mucous membrane of the pharynx and larynx is, pathologically, similar to the same malady when situated on the skin. It occurs either primarily or by extension from the face along the mucous tracts of the mouth, nose, or ear. Its causes are the same as those which give rise to it when situated upon the external parts of the body, although it has been most often observed in the course of general epidemics of the disease. Of eighteen patients seen by Cornil, in whom the pharynx was affected, fifteen were under the age of thirty, and twelve were females. Upon inspection of the pharynx, the appearance of the mucous membrane, when affected with erysipelas, differs considerably according to the form of the disease which is present; the local phenomena are generally very different from those of simple inflammation, but sometimes cannot be distinguished from it.

Cornil makes three divisions of the malady, viz., (1) Erysipelas with simple redness; (2) erysipelas with phlyctenulæ; and (3) erysipelas terminating in gangrene. Erysipelas most commonly reaches the larynx from the pharynx, but the former organ may be primarily affected while the pharynx remains healthy. The disease may extend still farther down the respiratory tract, and become associated with pulmonary congestion and edema. In cases which come under the first division the diagnosis must remain doubtful, except when the throat lesion is accompanied by manifestations upon the skin.

Erysipelas of the head and neck is often accompanied by more or less congestion of the mucous membrane of the larynx. The symptoms are dysphagia, hoarseness or loss of voice, and pain, increased on pressure from without. Sometimes the disease is much more active, and may result in acute edema, tending rapidly to a fatal termination. It is believed by some that the so-called primary edema of the larynx, or phlegmonous laryngitis, corresponds clinically to a localization of erysipelas in the larynx, and that many cases reputed as primary edema of the larynx are in reality erysipelas. The two affections seem at least to be closely allied.

As to the prognosis, the dictum of Hippocrates—namely, "When erysipelas extends from within outward it is a favorable symptom, but when it removes to the internal surfaces it is a deadly one"—has been confirmed by modern observation. In nine cases analyzed by Cornil, in which the face was first attacked, seven deaths occurred; whereas in nine other instances in which the enanthem preceded the skin eruption, seven recoveries took place. Mackenzie saw but four cases in the whole course of his practice.

The treatment must be both local and constitutional. The latter should be guided by the general principles which govern the management of the disease in other parts of the body. (*Vide* article on *Erysipelas.*)

As to local treatment, the application of cold to the throat, by allowing cracked ice to dissolve in the mouth, should be practised as long as there is any hope of checking the inflammation. Mild alkaline sprays, with a small amount of alcohol, have an excellent effect. A twenty-five per cent. solution of icthyol, in proper combination has been used with good effect. A solution of morphine applied in the form of spray is recommended by Mackenzie. Care must be observed lest the patient be unintentionally narcotized. Should the disease progress and tumefaction of the mucous membrane of the larynx take place, the conditions become similar to those found in acute edema of the larynx. (*Vide* also article on *Laryngitis, Acute.*)

D. Bryson Delavan.

Larynx, Foreign Bodies in.—See *Air Passages, etc.*

Larynx, Fractures and Dislocations of the.—These injuries, although rare, may occur from several causes, namely, violent manual compression, falls, accidents with machines, rolling vehicles, hanging, etc. Of fifty-two cases collected by Hénocque, the thyroid alone was fractured in twenty-three, the cricoid alone in seven, both of these cartilages in seven, while in the rest the hyoid bone, larynx, and trachea were all involved in a common injury. A direct blow upon the larynx may produce a contusion of the soft parts, but can hardly result in fracture, unless the organ is supported to some extent upon the spinal column. Ossification of the cartilages will necessarily render them more liable to injury.

The symptoms are pain and tenderness, dyspnea, expectoration of bloody mucus, and cough, with, sometimes, emphysema of the neighboring areolar tissue. Crepitation and, occasionally, overriding of the fractured edges may also be felt. These symptoms are sometimes so slight as to be hardly recognizable, the patient making a rapid recovery. As a rule they are severe from the first or gradually become so from the development of endolaryngeal extravasation, edema, or the displacement of fractured parts. Any of these things may cause death

by asphyxia. Later, the danger is from abscess, necrosis, and cicatrical stenosis of the larynx. The latter may necessitate the permanent wearing of a tracheal cannula.

The PROGNOSIS is very grave, especially in fracture of the cricoid.

TREATMENT. Unless the symptoms are not urgent, tracheotomy should be performed at once, or intubation of the larynx may be resorted to, with the same object in view.

Should the cartilages be much crushed, Clinton Wagner, having done tracheotomy and inserted a tampon cannula, divides the larynx in the median line, separates the thyroid, asepticizes the wound; replaces or removes the fragments of cartilage and packs the cavity of the larynx with iodoform gauze. In extreme cases, extirpation of the larynx or resection may have a future. Panas advises that in some cases the fragments be kept in place, and the patency of the laryngeal canal preserved by the introduction of a small, hollow, india-rubber plug into the larynx from the tracheal opening, and its subsequent inflation. Leeches to the neck, and ice, both externally and internally, will sometimes prove of service.

Intralaryngeal *dislocations* of the larynx are extremely rare. They are generally of the arytenoids and due to cicatricial contraction.

Fracture of the Trachea, a rare injury, is sometimes associated with that of the larynx. As the fracture occurs in the cervical region the edges of the lesion are apt to be inverted and to cause obstruction. It is sometimes found at the bifurcation. The symptoms are dyspnea, extravasation, and emphysema, with pain on pressure over the seat of the fracture. The prognosis is bad. The patient should be kept completely quiet and, if dyspnea appear, tracheotomy should be performed and a cannula long enough to reach below the obstruction should be inserted.

D. BRYSON DELAVAN.

Larynx, Inflammation of the.—See *Laryngitis*.

Larynx, Lupus of the.—*Definition.*—Lupus is a form of tuberculosis caused by a bacillus with attenuated virulence or with not sufficient virulence to produce real tuberculosis in an infected organism. It is almost always secondary to lupus of the skin or mucous membrane and is of such slow growth and so devoid of symptoms that in nearly every instance its discovery is quite accidental.

ETIOLOGY.—It is generally believed to be due to an infection from without. This is shown by the fact that in most of the lupus cases the lungs are not found affected and also by the fact that the picture of metastatic tuberculosis of the skin differs entirely from that of lupus.

It occurs most frequently in females and in a few cases occurs as a primary disease.

I have recorded[1] two cases of this affection occurring primarily in the larynx and where eventually tuberculosis of the lungs ensued, one of these was under observation for eighteen years. The total number of cases of primary lupus of the larynx recorded up to the present time is thirty-five.

PATHOLOGY.—In this form soft polypoid excrescences which may become confluent forming tumor-like areas are frequently mistaken for carcinoma. These change into masses with secreting surfaces with indolent edges, and may become cicatrized. In these cicatrized areas small brown excrescences may occasionally crop up. This cicatrization may cause marked malformation of the larynx. Lesions in this variety, in contradistinction to the usual form of tubercular lesion of the larynx, are not surrounded by an area of marked infiltration nor have they cheesy bases. The course is a very chronic one. It is frequently mistaken for syphilis.

The epiglottis is the most frequent site and in the earliest stage shows an enormous thickening on each side with a depression at its center so that it has a saddle bag appearance. Later on the swelling increases, the edges become eroded and ulcerated and the arytenoids become affected (Plate XLII, Fig. 4).

SYMPTOMS. The symptoms of lupus of the larynx are remarkably few, and as has been previously stated its discovery is quite accidental because of this fact. It is indeed remarkable that there is neither dysphagia nor dyspnea associated with the great amount of induration and ultimate destruction that often exists in lupus of the larynx.

DIAGNOSIS. Every writer, with but a single exception, who has presented the subject of lupus of the larynx is heartily in favor of keeping up the differentiation in the nomenclature between lupus and *tuberculosis*. Differentiation between lupus and tuberculosis should not be difficult clinically. While primary tuberculosis of the larynx does exist, it is comparatively rare, so that usually the tuberculous larynx follows pulmonary tuberculosis.

To the patient already exhausted form the ravages of pulmonary tuberculosis now comes a disease that affects his speech, his deglutition, and his breathing. There is always pain, and only the most energetic careful measures are of avail here, and the fewest of the patients are given the opportunity of receiving skilful treatment from trained hands.

On the other hand, with the most formidable destruction lupus is painless, there is no loss of weight, there is no cough, and in each instance the prognosis is declared as being good so far as life is concerned. If the patient with laryngeal tuberculosis does not improve, the end mercifully is not far off.

From *syphilis* the differentiation is readily made; history, site, the Wassermann reaction or antisyphilitic treatment may all be necessary before final conclusion is reached.

From *epithelioma* differentiation may be made by the age of the patient, lupus occurring in early life, as also the absence of symptoms, slow development and in each instance microscopical examination confirms the diagnosis.

Lupus of the larynx is compared with lupus vulgaris of the skin, ulcerative tuberculosis of the larynx with the same condition in the skin, and tuberculosis laryngeal tumor with scrofuloderma. I quite agree with those who desire to keep a distinction between lupus and tuberculosis, notwithstanding their similarity in so many other respects.

TREATMENT.—Treatment may be either medical or surgical. Pfannenstill[2] has had excellent results in cases treated by him in the Finsen Light Institute in Copenhagen. His method consists in the internal administration of the iodide of sodium, two grams (thirty grains) daily. Subsequently the patient is given inhalations of ozone or where this may not be practicable, the application of an acidulated solution of hydrogen dioxide is made directly to the affected part. The result of this combination is the liberation of free iodine which has a strong bactericidal effect. Strandberg[3] has used this method and extols it.

Following this suggestion Mandl[4] has presented a preparation called ulsanin which is a hydro-iodoborate. It is powerfully hygroscopic and hence must not be permitted to become moistened in any way before being applied directly to the diseased parts.

Permanganate of potassium is suggested as a local application by Katschanowski.[5]

Koichi Fujinami[6] has a new method of treating lupus of the larynx with the parallel rays of the Finsen lamp. A funnel is added to the distal end of the apparatus with water flowing about the mouth

end. The patient is seated, tongue protruded, the funnel end inserted in the mouth, set with a thumbscrew. A laryngeal mirror with a reflector enables the patient to see the apparatus *in situ*. At first the treatment is given once daily of three to five minutes duration only, as soon as the patient is accustomed to the discomfort of the tongue and pressure of the mirror, the sittings are increased to from fifteen to twenty minutes. Reaction in the shape of pain in deglutition, redness and tumefaction occurs after five to six treatments, and from this time improvement in the diseased part begins and at this time the treatment must be temporarily discontinued.

Albanus[7] recommends the use of the high frequency current, while Safranek[8] advises the use of superheated air and to reach this a laryngo fissure should be performed.

Treatment by tuberculin, if used at all in these patients, should be given in minutest doses as it must be borne in mind that laryngeal edema follows the administration of tuberculin, adding naturally to the already existing stenosis.

Operative treatment gives the surest and quickest results, radical removal of all the diseased parts, preferably under suspension laryngoscopy followed by the galvanocautery and lactic acid under either local anesthesia, general anesthesia or in what is the most recent method, of rectal anesthesia. Guild[9] records a case of lupus of the larynx on whom he performed tracheotomy, thyrotomy and removal of diseased tissues with no recurrence after eight years. Supportive treatment must not be neglected.

EMIL MAYER.

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Larynx, Neuroses of the.—Neuroses of the larynx may be divided into two groups, motor and sensory, the first comprising paralyses and spasms (chorea, nervous cough, dysphonia spastica, and laryngeal vertigo); the second, anesthesia, paresthesia, hyperesthesia, and neuralgia.

They are also sometimes classified under the titles Functional and Organic.

PARALYSIS OF THE RECURRENT LARYNGEAL NERVE.—The recurrent laryngeal nerves, branches of the vagus, supply all the intrinsic muscles of the larynx with the exception of the cricothyroids.

Etiology.—The recurrent nerves may undergo degeneration as a result of disease in the vagus centers or in the peripheral course of the nerves. Owing to its longer and more exposed distribution the left recurrent nerve is more prone to compression than the right.

Among the bulbar lesions concerned are tabes dorsalis, syringomyelia, hemorrhage, softening, tumors, and bulbar paralysis.

The vagus may be involved in tumors or injuries at the base of the skull.

The recurrent nerves in the neck may become compressed by goiters (especially in malignant disease) or by foreign bodies in the esophagus or may become enmeshed in malignant disease of the hypopharynx or esophagus. Wounds of the neck or accidental injury during goiter or other operations may involve the nerve.

The most common cause of left recurrent paralysis is aneurysm of the transverse arch of the aorta. The right recurrent is occasionally affected by pleuritic adhesions at the apex of the lung or by aneurysm of the subclavian.

Enlarged bronchial glands, mediastinal tumors, hypertrophy of the left auricle, and pericarditis may act as causes.

A neuritis may result from diphtheria, syphilis, influenza, lead, arsenic, etc.

Symptoms. Paralysis of the recurrent may exist without any subjective symptoms. At other times the patient complains of a change in voice or of a sense of fatigue when using the voice or of weakness in the tones. Occasionally complete aphonia may result. A cough may be present. Dyspnea is absent unless excited by the underlying cause (aneurysm, etc.). Associated paralysis of the spinal accessory on the same side may be present (trapezius, sternocleidomastoid).

Laryngoscopic Examination.—The first effect of a lesion of the recurrent nerve or its bulbar center is manifested by a paralysis of the abductor muscle on the same side. (Semon's law, see below.) When the paralysis is complete the affected cord is found immobile in the cadaveric position (midway between the phonatory and respiratory positions).

The corresponding arytenoid usually is tilted slightly forward into the larynx.

During inspiration the glottic opening has the outline of a right-angled triangle of which the paralyzed cord constitutes the base (Plate XLI, Fig. 13).

During phonation the unaffected cord moves as far as the median line and when "compensation" has taken place, may cross over to come in contact with the paralyzed cord. This gives rise to an oblique glottic chink. The unaffected arytenoid may cross behind the fixed arytenoid at the same time (Fig. 14). The rare condition of bilateral paralysis is illustrated by Fig. 15.

Diagnosis.—The diagnosis is made from the laryngoscopic examination. The cause is determined by a careful examination of the neck, thorax, and central nervous system. In obscure cases the writer has found radiograms of the neck and chest invaluable aids to diagnosis.

Prognosis and Treatment.—The prognosis and treatment depend upon the underlying cause. Cases of short standing due to compression by tumors may return to normal after the tumor has been removed. Injury to the nerve during operation may be recovered from if the nerve has not been severed. Cases due to diphtheria require antitoxin. Lead and arsenic poisoning require appropriate treatment.

In syphilitic cases salvarsan is indicated and in selected cases salvarsanized serum should be injected intraspinously.

In selected cases associated with a flabby cord and aphonia Bruennings has injected paraffin into the paralyzed cord. Navratil has proposed an anastomosis between the descending hypoglossal and paralyzed recurrent nerve.

ABDUCTOR PARALYSIS.—Paralysis of the cricoarytenoideus posticus, the "respiratory muscle," is an important lesion of the larynx. Its early detection frequently leads the way to the discovery of some overlooked lesion in the central nervous system or in the neck or thorax. Undiscovered bilateral abductor paralysis menaces the life of the individual. Tabes and malignant disease of the hypopharynx are the two most common causes of bilateral paralyses.

Etiology.—The causes of this form of paralysis are the same as those of paralysis of the recurrent laryngeal nerves (*q.v.*), for according to Semon's law, in all organic progressive lesions which affect the ganglia or branches of the motor nerves of the larynx, the abductor branches and muscles are involved before the adductors.

Symptoms.—Unilateral posticus paralysis frequently

exists without any symptoms whatever, since the affected cord remains fixed in the median line and phonation is not impaired while the free abduction of the sound cord provides a sufficient opening for ordinary respiration (Fig. 9).

Bilateral abductor paralysis usually produces a characteristic group of symptoms. Phonation and even singing may be unimpaired, but dyspnea occurs on the slightest exertion and in fully developed cases becomes extreme.

Inspiration is accompanied by a loud, coarse, long-drawn stridor which is more pronounced during sleep when voluntary control of respiration is abolished. This laryngeal snoring in such cases is loud enough to disturb greatly those in the same ward as the patient.

A slight catarrhal inflammation may aggravate the symptoms and cause asphyxia. In a case now under the writer's care the patient was admitted to the hospital after a brief bronchoscopic examination which so increased the dyspnea that tracheotomy was imperative.

Laryngoscopic examination reveals a strange phenomenon; during inspiration the cords remain in the phonatory position and their edges are seen to roll in and narrow the glottic chink, while during expiration the edges roll outward, slightly widening the orifice (vicarious movements of the cords, Figs. 10 and 11).

Diagnosis.—Unilateral abductor paralysis must be distinguished from recurrent paralysis in which the cord remains in the cadaveric position. Ankylosis of the arytenoid must be differentiated as described under that caption.

Bilateral paralysis usually presents characteristic subjective and objective symptoms, although unsuspected cases have been found in routine examinations of ward patients in hospitals for nervous diseases (Freudenthal).

Treatment.—Unilateral paralysis requires no especial treatment. In bilateral paralysis tracheotomy is often imperative and should usually be done as a prophylactic measure. The writer has a patient who has worn a cannula continuously for six years with but slight change in the laryngeal condition.

Bilateral chordectomy may be undertaken if the patient refuses to wear a cannula permanently (Gleitsmann).

Paralysis of the Tensors of the Larynx.—*I. Cricothyroid Paralysis.*—This is a rare condition. It may follow diphtheria or trauma or tumors involving the superior laryngeal nerve.

Symptoms.—The voice is roughened and may be weakened and the higher tones are impaired. The laryngoscope shows the cord on the affected side somewhat relaxed and wavy in outline during phonation (Fig. 1). If the internal branch of the superior laryngeal is involved anesthesia of the larynx is also present.

Diagnosis.—For the diagnosis of a bilateral paralysis, radiography of the larynx or palpation in the cricothyroid space should show the absence of elevation of the cricoid cartilage during phonation.

Treatment.—Treatment should include diphtheria antitoxin, electricity, and massage.

II. Internus Paralysis.—This may occur as a paresis with acute or chronic laryngitis and is then due to the inflammatory process involving the underlying muscle directly. It follows straining the voice and may be present in general weakness, anemia, or tuberculosis, and as a secondary phase of progressive abductor paralysis. (Semon.) (See Figs. 2 and 12.)

Symptoms.—The voice is weak and hoarse and prolonged speaking is difficult.

The laryngoscope shows that the cords fail to approximate accurately during phonation, leaving an elliptical cleft between them (Fig. 2).

Treatment.—Acute or chronic laryngitis should be treated. Electric stimulation may be applied externally or one electrode may be introduced into the larynx. Fresh air, general hygiene and tonics containing strychnine, iron, or hypophosphites may be administered.

Paralysis of Transverse Arytenoideus.—This is due to the same causes as internus paralysis and is often associated with the latter. The laryngoscope shows a V-shaped slit between the arytenoids (Figs. 3, 5, 7, and 8).

Paralysis of the Adductor Group.—*Etiology.*—The adductors of the cords become paretic as a result of some functional neurosis, chiefly hysteria. The condition is not uncommon. (Hysterical aphonia.) It occurs particularly in females, and may be induced by fright or trauma.

Symptoms.—The symptoms come on suddenly, aphonia may be complete or the voice reduced to a whisper. The voice may suddenly return. Other hysterical stigmata may be present.

The laryngoscope shows normal inspiratory movements, but on attempts at phonation both cords fail to remain in contact and the expired air escapes rapidly without effective sound production (Fig. 4). By suggestion during the examination the patient may often be made to overcome the paresis.

Treatment.—By means of suggestion, such as firmly holding the larynx, the voice may be restored. Gradual training of the voice beginning with vowel sounds is often effective.

Loeb has obtained good results by forcibly depressing the epiglottis over the larynx while calling upon the patient to phonate. Intralaryngeal or external faradization is of great value. The psychic condition requires appropriate management as well as the reflex cause of the hysteria.

Spasmodic Affections of the Larynx.—Spasm of the larynx may occur as laryngismus stridulus in children (which is described in the article on *Croup*). A similar disease, spasm of the glottis, occurs in adults. Dysphonia spastica, chorea, nervous cough, and laryngeal vertigo should also be considered under this heading.

Spasms of the Glottis.—Etiology.—Hysteria is often the underlying cause. Spasm may occur in the laryngeal crises of tabes. It may constitute a symptom of tetanus, epilepsy, hydrophobia or chorea.

Gas or concentrated anesthetic vapors or the entrance of a foreign body into the larynx may excite severe spasm. Nitrate of silver solutions act in the same manner.

Symptoms.—Spasm of the larynx is characterized by its sudden onset. Inspiration is suspended or interrupted by short stridulous sounds. The facial expression indicates great anxiety. All of the symptoms usually subside after a very brief interval. In rare cases asphyxia may occur. According to Schmidt, air may be drawn into the stomach during the forced inspiration and is later expelled as ructus.

When laryngoscopy is possible the cords are seen firmly pressed together and even slightly overlapped.

Treatment.—During the attack if the patient be instructed not to attempt to breathe for a few seconds the spasm will usually cease. Cold water to the face and head, smelling salts, and the like may be of service. Schmidt recommends depressing the epiglottis with the finger to relieve the spasm. In the laryngeal crises of tabes, Williams found amyl nitrite inhalations would give marked relief. Cocaine may be applied to the larynx. Bromides, belladonna, tonics may be given between attacks.

Dysphonia Spastica.—In this condition when the patient, usually an adult, begins to speak, the vocal bands become so firmly pressed together that speech becomes jerky or impossible. The larynx functionates normally when no attempt is made at phonation.

EXPLANATION OF PLATE XLI.

POSITION OF THE VOCAL CORDS DURING PHONATION OR RESPIRATION IN PARALYSIS OF THE MUSCLES NAMED.

FIG. 1.—Right and left cricothyroid; phonation

FIG. 2.—Right and left internus (vocalis); phonation

FIG. 3.—Right and left transversus; phonation

FIG. 4.—Right and left lateralis; phonation

FIG. 5.—Right and left internus (vocalis) and transversus; phonation

FIG. 6.—Right and left internus (vocalis) and lateralis; phonation

FIG. 7.—Right and left transversus and lateralis; phonation

FIG. 8.—Right and left internus, transversus, and lateralis; phonation

FIG. 9.—Left posticus; respiration

FIG. 10.—Right and left posticus; respiration

FIG. 11.—Right and left posticus; phonation

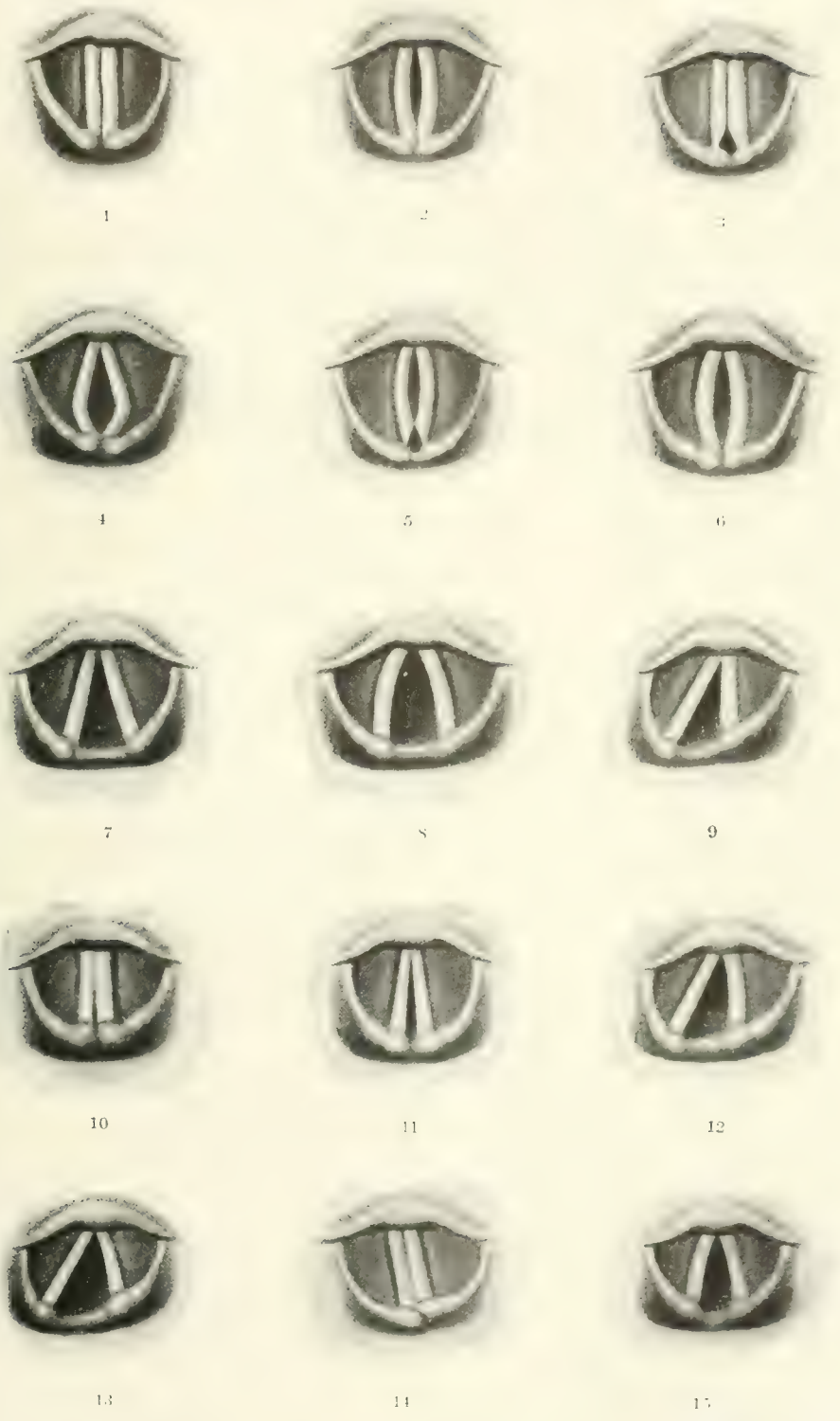
FIG. 12.—Left posticus and internus; respiration

FIG. 13.—Left internus, transversus, lateralis, and posticus; respiration

FIG. 14.—Left internus, transversus, lateralis, and posticus; phonation

FIG. 15.—Right and left internus, transversus, lateralis, and posticus; respiration and phonation

FIGS. 13, 14, AND 15.—Paralysis of the recurrent laryngeal nerve



VARYING POSITIONS OF THE VOCAL CORDS DURING PHONATION OR RESPIRATION IN PARALYSIS OF THE LARYNGEAL MUSCLES

(*Moritz Schmidt — Krankheiten der oberen Luftwege*)

Breathing exercises and elocutionary training are indicated in the treatment.

Chorea Laryngis.—Ataxic movements of the vocal cords may occur as a symptom in a number of diseases, such as paralysis agitans, multiple sclerosis, tabes, etc. The term chorea laryngis should be limited to the irregular twitching movements of the vocal bands which occasionally are present in true cases of chorea. The voice is weakened and speech is jerky owing to the incoordination of the laryngeal muscles. The treatment is that of the causal disease.

Nervous Laryngeal Cough.—This condition occurs chiefly at the time of puberty in both sexes and has been given the title of barking cough of puberty (Clark).

Overeating and alcohol play a rôle in its production. It occurs chiefly in neurotic persons and Semon and Williams regard it as "one of the convulsive tics," while Schroetter classified it as a form of chorea.

Symptoms.—The disease is characterized by a loud barking cough, which occurs without the expectoration of mucus. It is present during the waking hours, but usually disappears during sleep. It may be present for weeks or months.

Diagnosis.—The diagnosis is made from the peculiar character of the cough and the absence of physical signs in the larynx and chest.

All reflex sources of cough such as nasal hyperesthesia, a foreign body in the ear, enlarged faucial or lingual tonsils, as well as an enlarged thymus or bronchial glands must be ruled out.

The treatment is difficult. Bromides or valerian may be tried, also iron or arsenic in various forms. Hydrotherapy may be of service. Frequently the patient must be removed from his home or his usual surroundings. According to Semon, a sea voyage acts like a charm in these cases.

Laryngeal Vertigo (*Ictus Laryngis*).—This is a rare and obscure spasmodic affection of the larynx, associated with a tickling sensation in the throat and an attempt at forced expiration or cough. Vertigo ensues and the patient may become unconscious for a very brief interval. By some this condition is regarded as a form of epilepsy with the aura in the larynx. The combination of forced expiration with a closed glottis and interference with the circulation probably explains the syncope.

Sensory Neuroses.—The larynx may be the seat of certain disorders of sensation. These include anesthesia, paresthesia, hyperesthesia, and neuralgia.

Anesthesia of the Larynx.—This condition results from a lesion involving the superior laryngeal nerve, and may follow diphtheria, influenza, or multiple neuritis. It may be present in bulbar paralysis, tabes, or syringomyelia. It is artificially induced for therapeutic purposes by injecting alcohol into the internal branch of the nerve.

Unilateral anesthesia usually passes unnoticed unless the interior of the larynx is touched with instruments. Bilateral anesthesia may lead to "swallowing the wrong way," and the danger of asphyxia or aspiration pneumonia.

Great precautions must be taken to prevent these complications. Anesthesia may be associated with cricothyroid paralysis (*q.v.*).

Paresthesia of the Larynx.—This usually occurs in hysteria or hypochondriasis and is often associated with cancerophobia.

The patient complains of a lump or dryness in the throat or of a tickling, scratching, or foreign body sensation. The symptoms may come and go. Laryngeal examination is usually negative, although some exciting cause may be found in the pharynx, the lingual tonsil, or some remote part of the body.

The treatment is chiefly by suggestion, although any abnormal condition which may be discovered in the pharynx or larynx requires local treatment.

Hyperesthesia of the Larynx.—Etiology.—The normal larynx varies exceedingly in its sensitiveness. Some persons can tolerate intralaryngeal manipulations with but little discomfort, while others have very active reflexes.

Hyperesthesia occurs in neurotic persons and in cases of acute or chronic laryngitis. Excessive smoking and drinking are potent factors. In tuberculosis of the larynx it is a common symptom.

Neuralgia.—Neuralgia may be due to rheumatism, gout, or anemia or may be the reflex manifestation of a lesion, such as a carious tooth or an inflamed tonsil.

Symptoms.—In hyperesthesia slight irritants such as smoke, dust, food, or laryngeal applications may bring on a spasm of the throat with a severe coughing fit and even vomiting.

With neuralgia there is paroxysmal pain radiating to the side of the neck and toward the ear, often with a tender spot at the outer border of the thyrohyoid membrane.

Treatment.—Smoking and drinking should be interdicted, as well as the taking of very hot food.

Pharyngitis and laryngitis require topical applications. A menthol spray may be ordered, or anesthesine may be prescribed. Antispasmodics, tonics, massage, fresh air, electricity are indicated. In severe neuralgia alcohol should be injected into the superior laryngeal nerve. Samuel Iglauer.

Larynx, New Growths of the.—Classification and History.—Laryngeal neoplasms, like tumors in any other portion of the body, are clinically divisible into benign and malignant growths, and this division, although based upon purely clinical knowledge, may with propriety be retained, as may also the purely anatomical division of laryngeal neoplasms into extrinsic and intrinsic (Grieshaber), namely, those which start from without the true anatomical confines of the laryngeal cavity and those which start from within that organ. Whether starting without or within the larynx proper the tumor is almost invariably a primary growth in that part. Its general anatomical situation is but little calculated to encourage metastasis from other organs.

Prelaryngoscopic records furnish but few instances in which intralaryngeal neoplasms were discovered and successfully removed during the life of the patients, but there are a few cases in which a tumor located high up in the larynx, or attached by a long pedicle so that it could be brought into view when the tongue was depressed, was diagnosed and removed. Most of these tumors were, however, first discovered post mortem, the clinical signs to which they had given rise during the lifetime of the patient having remained unappreciated. Middeldorpf in 1854 collected the histories of all the cases then on record, sixty-four in number, in nine only of which had any attempt been made to remove the neoplasm. To Kaderik in 1750 is due the credit of having removed a laryngeal tumor *per vias naturales*. Seventeen years later, Lieutard reported two undoubted cases of the same nature. Brauers in 1833 attempted to remove a laryngeal neoplasm by thyrotomy, and Regnoli in 1836 succeeded after a preliminary tracheotomy in extirpating a growth through the mouth. In 1837 an instructive case of primary cancer of the larynx was reported by Trousseau, and soon thereafter Louis and Barth each reported a case. A little later we find a description of laryngeal tumors in Ryland's classical work, and after a long interval Ehrmann's celebrated treatise appeared (1850), containing a description of thirty-one cases. To these, in 1851, Rokitansky added ten cases. Green followed in 1852 with thirty-nine cases, Gurdon Buck in 1853 with forty-nine, and finally Middeldorpf in 1854 with sixty-four, bringing the history of these neoplasms down to the date of the introduction of the laryngoscope into medical practice in 1858.

From this date the subject enters into an entirely new phase; its historical interest ceases, while its practical importance begins to develop. The rapid progress in special knowledge, resulting in an immense increase in the number of laryngeal tumors diagnosed, and the impetus given to intralaryngeal surgery by the success of von Bruns in removing a laryngeal fibroma by the natural passages with the aid of the laryngoscope (1861), have all been the natural outcome of the discovery of this instrument.

Etiology.—Concerning the causation of new growths in the larynx region but little is known, if we exclude those pathological changes which come in syphilis and tuberculosis. However, there is an evident tendency in the writings on this subject to lay some stress on the probability that any form of chronic irritation, wrong or overuse of the voice (chronic traumatism of Seiler), prolonged exposure to dust, smoke, or irritating vapors, make an influence for the production of the neoplasm. But this can never be the sole cause and we must always bring in the special susceptibility of the individual at a given period and of the tissues in this particular region to make these indirect causes operative. Even then it would be, for instance, quite difficult to conceive how use of the voice by a faulty method could account for the frequency of papillomata in babyhood and early childhood, or produce the large fibromata sometimes found in the adult, or explain the well-known and remarkable case of Morrell Mackenzie, where a papilloma formed in a deaf mute. Yet this same abuse of the vocal cords in singing will produce nodes. These can become at times quite large, and are real hypertrophies of the particular tissue involved. There also apparently seems to be a greater frequency of malignant growths in those who make much use of the organs of speech. And yet males apparently have more malignant disease in the larynx than the supposedly more loquacious females.

Concerning the malignant growths which are the result of increased proliferation of the changed cells of the tissues of the larynx, not much more is known at the present time, in spite of all the enormous amount of work which has been done in the last ten years on the subject of the causation of cancer. Even since the cultivation of generations upon generations of cancerous growths in mice, with the flood of facts discovered thereby, nothing very definite has been made known to help us see why one man has a cancer and the others not. And though writing at a much later date than Seiler, the author of the article in the previous edition of this work, I cannot say anything more definite than he when he wrote: "We may assume, however, with propriety, that in certain persons a condition of the system exists which predisposes them to localized cell proliferation and therefore to the formation of neoplasms. These will naturally form in such portions of the body and such tissues as are subjected to local irritation, and in this connection it is well to remember that some individuals are more prone to the development of local accumulations of embryonal cells (carcinoma and sarcoma), while others, probably of a more vigorous constitution, are more prone to the development of local hyperplasiæ of fully formed tissue cells (fibroma, lipoma, papilloma, etc.).

"It is in the instance of papillomata that we find a line of demarcation distinctly drawn between the benign and the malignant tumors, for, as Nancrede has pointed out, a given subject with a predisposition to the development of papillomata will develop such growths only in early life; but this dyscrasia, if it exerts its influence in later life, when the superficial epithelial layers of the skin and mucous membrane have become hardened and indurated, while, at the same time, the connective-tissue layer of the subdermal and submucous tissues has become weakened, will result in a malignant epitheliomatous growth, the cell proliferation following the line of least resistance and invading tissues where epithelial cells do not properly belong."

Concerning the possibility of benign changing to malignant growths, the writer holds that if any chronic traumatism can be ever reasoned to be indirectly causative of a malignant growth being formed from previous normal tissues, the same process must, logically, be equally, if not more easily able to change a benign growth—normal tissue already overactive—into a malignancy. And *a propos* of the nature of papillomatous tissue in general, every observer of much experience will have chronicled how frequently a part of the larynx, as for example, the opposite cord is so liable to have a growth occur where it has been rubbed by a warty growth on the other side, and if he operates often, even if ever so carefully, he will be compelled to have chronicled that whenever he has wounded the tissue of the larynx in his endeavors to remove papillomata, there he may later find a new papilloma appearing. Also, it has been observed that when attempts at treatment have been made too frequently or too violently, tremendous rapidity of growth, if not a real change to malignancy, may be provoked. This last was said to be the fact in the celebrated case of the Emperor Friedrich of Germany. Therefore, it is not so far a cry to believe that chronic daily mild irritation might produce similar effect in the tissues of a benign tumor as it has been credited with doing in normal tissues, and if this is true it is possible for a benign to change into a malignant growth. This would also apparently explain certain instances which arise in the experience of every one who does much microscopical work on tumors of the larynx when sections taken from one portion of growth have nothing about them in the slightest degree suggestive of malignancy[2] while sections from another part are so evidently malignant in character that the merest tyro could not fail to recognize their nature. In two instances in the writer's experience the benign section came from a part of the growth known to have been in existence at least two years; while the "malignant" ones came from the more recently grown portions taken after the growth had been removed by thyrotomy. One could here perfectly rationally and logically speak of a change to malignancy. Apparently, at least, both processes were present at the same time.

Frequency.—No statistics seem of much value regarding relative frequency as compared with other troubles in the general run of cases as they occur in either private or hospital practice. Certain generalizations are, however, permitted, to the effect that males seem to be more frequently affected than females; and that though cancer is looked upon as being much more frequent to-day than twenty years ago, still, there has surely, in the experience of myself of over thirty years, and that of others, seemed to be almost a falling off of cancer in the larynx, and perhaps of tumors of this region in general. There is a time-honored belief that singers and speakers seem to suffer most frequently from laryngeal neoplasms. Upon mature reflection the writer has come to the belief, however, that this is more seeming than real, because these people notice and seek professional advice for hoarseness much quicker than would the ordinary run of individuals, who, as happened in two recent cases, allowed a growth to exist for two or three years without bothering to consult anyone until they came to the writer. Also in cases of serious trouble with the larynx it makes so much more comment in a noted singer or public speaker than in others. Excepting, however, these speakers, singers, and hawkers—those who at times use their voice with violence—vocation, heredity, and climatic influence seem not to provoke any greater frequency of growths than the average. Statistics seem to show in France and Germany a greater frequency than with us for all

mucous membrane tumors but this might prove to be more apparent than real if our statistics were carefully compiled.

Clinical and Pathological Aspect of Laryngeal Neoplasms.—The present author, like the writer on this subject in the former edition, thinks that it will be best in this brief article, to combine the clinical aspect, the location, and the histological distinction between the different growths under one head, and begins the description of those which are benign with the neoplasm most frequently met with, namely, papilloma.

Papilloma.—Papillomata, in order of frequency, assume the first rank, not only in adults, but especially in children. They vary greatly in size, viz., from a millet seed to a walnut. Their most common situation is on the anterior two-thirds of the vocal cords; on the ventricular bands they occur more rarely; and they are hardly ever seen in the posterior commissure or in the posterior portions of the larynx. On the epiglottis they are seldom observed. Histologically they differ in no wise from papillomata found in mucous membrane elsewhere. In fact they might be taken as standard of their type.

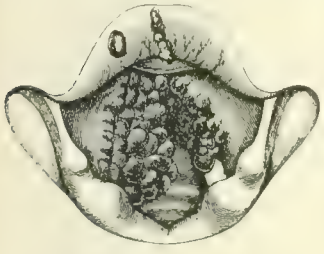


Fig. 3680.—Papillomata on the Vocal Cords.

Clinically, three varieties of these tumors are met with: The first class includes small light-red tumors of uneven surface and broad base, generally scattered and never of great size. After removal their recurrence is unusual. The second variety is a whitish-gray (the white growths are frequently mistaken for condylomata), papillary, warty tumor, seated upon a broad base and springing usually from the vocal cords. It recurs very slowly after removal, if at all. The third form, the most intractable as regards recurrence, as well as the most numerous, is the large reddish tumor, single or multiple, variously designated by different authors as cauliflower, raspberry, strawberry, mulberry, etc. They grow rapidly and invade all parts of the laryngeal cavity. These papillary growths, when they have assumed considerable size, become dangerous, not because of any tendency to carcinomatous degeneration, but on account of their bulk, by which they obstruct normal respiration, causing dyspnea or even apnea. They are sometimes ulcerated in consequence of necrosis of the superficial cells resulting from the insufficient blood supply. The latter fact is in all probability due to the constriction of the supplying blood-vessels in the usually slender stem of these growths, this constriction being caused by the pressure exerted by the growths themselves upon the surrounding tissue.

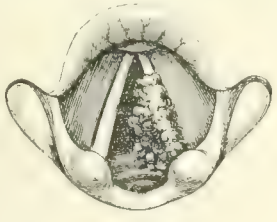


Fig. 3681.—Papillomata on the Right Ventricle of Morgagni.

Fibromata.—These growths are second in order of frequency. They are usually red in color. They are as a rule sessile when located, as they usually are, on the vocal cords, but may be occasionally met with as pedunculated growths especially when they occur in or near the anterior commissure. Here they often drop down out of sight during inspiration to pop up between and upon its vocal cords during forceful phonation. In this locality also the larger intrinsic tumors of this type appear. The writer once removed one attached to the anterior surface of the larynx which had a pedicle over half an inch in width in the vertical direction at the point of attachment. The flat tumor was an inch and a quarter long, nearly three-quarters of an inch broad, and at its thickest portion nearly one-half an inch. There was strangely not much bleeding from so broad a base on removal with a cold snare. They may be regarded as intrinsic neoplasms when they are attached to the cartilaginous structures of the larynx, namely, the perichondrium of the epiglottis, the arytenoid cartilages, or the cricoid; or as extrinsic when they spring from the lingual face of the epiglottis, the aryepiglottic fold, the hyoid bone, the larger cornua of the thyroid cartilage, or the articulation of the thyroid ligament. Their surface is smooth, they always occur singly in the larynx, and they are of slow growth. After removal they have no tendency to recur.

Histologically, the hard fibroid tumor is made up of interlacing bundles of white fibrous tissue generally covered by several layers of epithelial cells. The softer forms of fibroma (sometimes called cellular fibroma) are largely made up of more or less developed fibrocellular tissue, diffused through the meshes of which is a quantity of serum-like fluid.

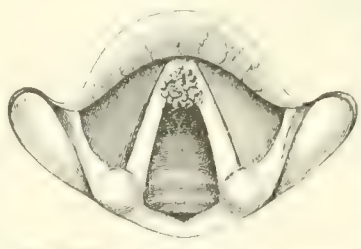


Fig. 3682.—Papilloma at the Angle of the Glottis.

The vascular supply of both varieties is but slight, and is always accomplished by anastomosis from the adjacent tissues on which these tumors are located, except in the rarer pedunculated variety, in which, as in the fibrous polypi of the nasal cavity, we not unfrequently find a large artery in the center of the pedicle which carries the blood supply to the neoplasm.

Cystic growths in the larynx rarely attain a large size. On the lingual face of the epiglottis, their favorite seat, they are usually seen of the size of a pea, although there are a few cases on record in which they have attained a size fully equal to half of a large hazel nut. Their color may be yellow or white. They have dense walls, and are filled with a thick gelatinous material. When situated on the vocal cords, they are always seen on the free edge, and their wall or enveloping membrane is much thinner than when they are situated elsewhere within the laryngeal cavity, because the epithelial covering of the vocal cords themselves is of a more delicate structure and of a different variety (squamous) from that of the epithelial covering of the rest of the surrounding mucous membrane. Rupture of these cysts is not unusual when they are seated in this locality. Cystic growths, when laid open and their contents emptied, show a tendency to recur, especially those with dense walls, unless something is done to destroy the lining or secreting membrane.

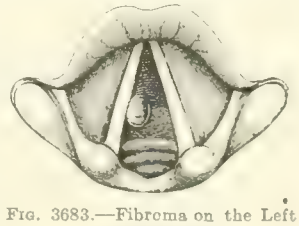


Fig. 3683.—Fibroma on the Left Vocal Cord.

Histologically, they belong to the class of retention cysts, and therefore it is natural that they should be most frequently located in those portions of the laryngeal cavity which abound in racemose glands, as the epiglottis, the aryepiglottic folds, the ventricular bands, and the ventricle of Morgagni. Some of the epiglottidean cysts seem to be quite like the branchial-cleft cysts, both macro- and microscopically.

A few cases of inversion of the ventricle have been reported (Cohen, Fauvel), and these—as Seiler has personally verified in an unreported case—closely resemble a cystic laryngeal neoplasm.

Lipoma.—Among the rarer forms of laryngeal neoplasms—which indeed are rarely seen even by the specialist—are such tumors as the lipomata, which are in this region perfectly typical fatty tumors.

Edematous fibromata, which are so frequently found within the nasal cavity in the shape of soft polypi, strange as it may seem, are very rarely seen in the larynx. They constitute the so-called polypi of the older writers. They are covered with a thin layer of epithelium and filled internally with delicate interlacing fibrous strands, the large meshes of which contain a gelatinous mucoid substance, exactly as are the similar growths in the middle meatus of the nose. In the larynx they rarely attain any great size. Their most frequent seat is the lower or laryngeal face of the epiglottis, or well down in the anterior commissure even below the vocal cords, where by their mechanical interference with the complete closure of the cords they cause partial or complete aphonia.

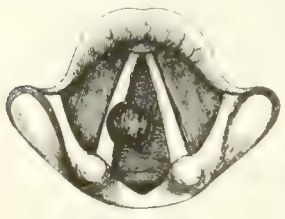


Fig. 3684.—Fibroma on the Left Vocal Cord; Growth of Larger Size.

Adenomata and *angiomata*, owing to the physiological function of the upper air passages, as well as to the anatomical structure of the larynx, are extremely rare, as are also *fibromyxomata*, of which a case was reported under that name by Seiler, and one of intercanicular fibroma, of doubtful diagnosis, by E. O. Shakespeare, and supposed at first to have been a case of angioma.

The present writer having seen several well-marked cases of angiomata feels quite sure that they are not as unique as at first supposed. Most writers make mention of ecchondroma occurring but they must be of the utmost rarity.

Malignant Tumors.—Two forms are recognized as occurring in the larynx, sarcoma and carcinoma. The former is very rarely seen, the present writer never having observed one undoubted case. It is described as occurring more frequently upon the false vocal cords or from the ventricles of the base of the epiglottis, and may be extrinsic, pushing in from the base of the tongue or tonsil. It seems to have been usually either of the spindle- or round-cell variety, but the mixed forms have been known to occur. Usually smooth and round, they may, however, in later stages present some ulceration.

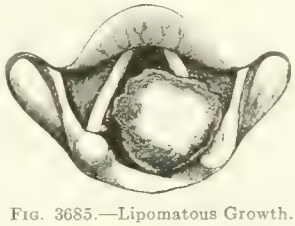


Fig. 3685.—Lipomatous Growth.

The epitheliomas are much more frequent. They begin more often on the vocal cords, not always upon the upper surfaces, or they occur in the ventricles or on the false cords. They are not infrequently extrinsic on the aryepiglottic fold, dipping down into the fossa leading toward the esophagus. Often when upon the vocal cords they present nothing different in appearance from the true papillomata, except perhaps that they are more sessile. During the early stages when diagnosis is difficult they are not as malignant, and may not recur when well taken care of. Later infiltration sets in at the base, the cord thickens up, the arytenoid swells, the surface ulcerates, and immobility of the affected cord occurs. When a rough growth of the cord is accompanied by some infiltration and sluggishness of motion in that arytenoid or of the whole cord in a person over forty, it is extremely presumptive that we have an epithelioma, even if the growth looks ever so benign, and even if there is no enlargement or hardening of the lymph nodes in the adjacent regions of the neck.

The one really positive diagnosis in early cases is to remove a bit of the growth from the most rapidly growing part of the mass, and even then it is often difficult to decide with all the help of microscopic study whether we surely have a cancer present.

Later still either the sarcoma or the epithelioma may develop actual metastases into other regions, may grow up and out from the larynx into other parts of the throat, or may break through the cartilages into the tissues of the neck. A true epithelioma may exist for a long period without any sign of enlarging the lymph nodes and then according to the situation of the tumor the glands involved, as shown by Crosby, Green, and others, will sometimes be those considerably above the level of the larynx or below it or both.

The differential diagnosis between carcinoma, syphilis, and tuberculosis is brought out with great clearness in the article in this same volume on tuberculosis of the larynx.

Symptomatology.—From what has already been said, in the above description of intralaryngeal neoplasms, it is plain that a very few words will suffice to convey to the reader the needed additional information in regard to the clinical picture presented by a given case of either a benign or a malignant laryngeal growth.

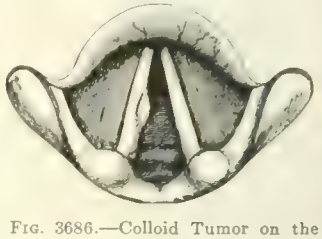


Fig. 3686.—Colloid Tumor on the Left Vocal Cord.

The only appreciated subjective symptoms are those of aphonia, dysphagia, and apnea, all three of which may vary in degree. Thus, for example, the aphonia may vary from a slight hoarseness to complete voicelessness. As regards the dysphagia there may, in one case, be merely a slight impediment in the act of deglutition (particularly of liquids), while in another there may be absolute inability to swallow either liquids or solids (aphagia). And, finally, there may be present symptoms of difficulty of breathing, such as shortness of breath in ascending stairs or slight elevations, usually aggravated by increase in atmospheric pressure, and then frequently mistaken (without a laryngoscopic examination) for asthma; or, in a more serious case, the difficulty may amount to absolute apnea. In such a case, as a matter of course, tracheotomy is not only indicated but should be at once performed, whether the necessary or so-called necessary instruments are at hand or not. I may add here that the operation of tracheotomy in the adult is by no means so serious and difficult a surgical procedure as it is usually supposed to be, especially in these days when local anesthesia, hypodermatically given, has been developed to its present state of perfection. Fauvel, Cohen, and Seiler have all mentioned in their works the fact that it is desirable for a person suffering from any intralaryngeal neoplasm to carry with him constantly the necessary instruments for tracheotomy. This is particularly to be urged in those cases of papilloma, sarcoma, cysts, and fibroma in which, either by direct obstruction of the rima glottidis or by reflex irritation of the abductors of the cords, sudden and very serious dyspnea may momentarily be expected to develop.

Pain as a subjective symptom is sometimes present in the benign form of neoplasms, but is always present,

to a greater or lesser degree, in cases of malignant tumors. It is of a neuralgic, lancinating, more or less intermittent character, and is usually felt in the region of the distribution of the different branches of Meckel's ganglion. In the case of extrinsic foci of sarcomata, carcinomata, or epitheliomata, the pain is referred by the patient to the middle portion of the external auditory meatus or else to the middle or inner ear, or to the mastoid process. Tuberculosis and syphilitic ulcerations, as well as foreign bodies embedded in either the tonsils or the faucial pillars, also give rise to similar sensations of pain in the same regions, but in none of these affections is the pain a severe or persistent one.

All other important points in the symptomatology have already been mentioned in the description of the different types of neoplasms of the larynx, and the local picture is so manifest to the eye of the observer, when the patient's larynx is exposed to view by means of the laryngoscope, that no further explanation is necessary. The general history of the patient and that of his family should be taken into consideration, particularly in regard to prognosis, and in doubtful cases, in which a differential diagnosis, by means of the general history, laryngoscopic inspection, or other evidence presented is apparently difficult to make, the laryngeal forceps, in the hands of the expert, can readily obtain sufficient tissue from the neoplastic formation for microscopic identification.

Prognosis.—In the case of the benign variety of laryngeal neoplasms, the prognosis, if the treatment is properly conducted, is invariably good. As before stated papillomata in young children present a very definitely different problem and the time limit is necessarily difficult to determine. Regarding malignant growths the outlook is much more cheerful than the one Seiler felt obliged to take when the second edition of this work was printed, which was "always bad." As already stated the excellent work of many operators proves conclusively that, early diagnosed, the growth can often be removed with no recurrence by simple thyrotomy. When it is more advanced, laryngectomy, if we can imitate the work of Glück, will be able to cure a great many sufferers.

Treatment.—While in general "a tumor is a tumor," and, according to Hippocrates, the father of medical law, as such is a superabundance of tissue and should therefore be removed, something more particular should be said concerning the various forms of benign and malignant growths.

In dealing with papillomata in young children; as has already been observed, a good deal of discretion must be used. It is often found that, whereas one takes away one growth it will return in half a dozen different places. In young children, for some years the accepted belief and treatment of many of the best men in the world has been to perform a tracheotomy, to which one is eventually almost always forced in dealing with them, and by rest of the larynx and noninterference, to keep the patient in health and good condition until such a time as the papillomata, by time limitation, will have gone away. It has long been observed that sometimes papillomata in young children, like warts in other situations, disappear without anything radical having been done for their removal.

It was formerly hoped when direct laryngoscopy came into vogue that our efforts might be more exact, more easily carried out, more effective, and thus we might save these children from going around with a tracheotomy tube for three, four, or five years, until this time limit should have expired and the growth cease to recur, but such hope has been dashed to the ground, and even the possibilities of suspension laryngoscopy it is feared will not live down this obstinacy in responding to therapeutic endeavors.

Abbe, Harris, Hopkins, and others have stated that they have cured certain cases of papillomata by one or a few exposures for a long period to radium emanations. The patient has been anesthetized, and while under the anesthetic the tube of radium has been placed within the larynx and held there for periods up to fifty minutes. Absolute cures in adults have been accomplished. It seems to me that although fulguration has been used in children to destroy the growths while they are still tracheotomized, it would be perfectly possible, in a tractable patient, through the tracheal opening, to introduce a tube of radium into the larynx and allow it to remain there over quite an extended period. Especially could this be accomplished if a slight amount of general anesthesia was also used. The writer has recently demonstrated the perfect feasibility of maintaining a patient perfectly quietly in position by suspension laryngoscopy for forty minutes, the anesthesia being the so-called pharyngeal insufflation through the double nasal catheter of warmed ether vapor, as developed by Flint. This particular statement is the only one of encouragement that the present state of our work offers in the care of these obstinate cases of recurring papillomata in children, or even in adults.

Generally, however, papillomata respond readily in the adult, to careful manipulation, and when, by either the direct or indirect method, the growth is removed and the base cauterized, then, as stated in the other part of the text, the growth may never recur.

Cystic growths, when it is at all possible, especially the larger ones which occur on the epiglottis, should be incised by the galvanocautery knife or point, and through such opening the attempt should be made to destroy the lining membrane, if one wishes to avoid the possibility of recurrence.

Fibromata, angiofibromata, and edematous fibromata are readily cared for, generally, by the use of the snare or appropriate forceps. Malignant growths cannot as a rule be treated by any so pacific means as simple, indirect laryngeal operations, although the author has twice succeeded in the case of early epithelioma.

So far as sarcoma is concerned, each case must be a law unto itself and no one rule can be laid down for all cases.

Concerning epithelioma, the writer feels positive that, if early diagnosis can be made, simple thyrotomy with removal of the growth, even if it includes the whole of the vocal cord down to the perichondrium, followed by thorough cauterization of all suspected areas with the galvanocautery or the thermocautery, presents possibilities of cure that should not be neglected. A number of patients in the writer's experience are still alive and without recurrence years after the removal of the growth in this way, and in many of them there has been restoration of a practically perfect voice by the formation of a cicatricial band in place of the removed vocal cord so that the function of the larynx has been perfectly preserved. Green reports most gratifying successes.

When the growth seems to be so large, in carcinoma, that thyrotomy cannot be depended upon to remove it, the writer feels that laryngectomy done by the method of Glück stands a better chance of saving the patient's life and having him comfortable and a useful member of the community than does any hemilaryngectomy or substitute operation. An intrinsic cancer of the larynx can be removed by laryngectomy, and if the neighboring glands are removed, the probability of cure is very good indeed, and as each year goes by the percentage of such cases which recover and live for years without recurrence grows notably greater and greater. Glück's latest statistics show sixty odd cases operated upon by laryngectomy with no operative deaths—a wonderful record. All of this points to establish the diagnosis

early and then act radically in the complete removal of cancer in this situation, as well as in all others.

HENRY L. SWAIN.

Larynx, Perichondritis of the.—Laryngeal perichondritis is an inflammation of the perichondrium which is prone to proceed to suppuration and to necrosis with exfoliation of the underlying cartilages. Suppuration, however, is not an invariable consequence, for resolution may occur or hyperplasia continue indefinitely.

ETIOLOGY.—*Primary acute perichondritis*, which is rare, may be ascribed to "cold" and vocal abuse, but only in the sense that these conditions act as factors which predispose to infection by pyogenic microorganisms. It may arise by continuity of tissue in phlegmonous laryngitis, abscess of the larynx, and suppurative inflammation in the cervical glands and tissues. It may be due, in either an acute or a chronic form, to rheumatic infection from the focal suppurations in retention tonsillitis, nasal accessory sinus disease, pyorrhea alveolaris, etc., also to gout and the condition termed arthritis deformans, eventuating then especially in cricoarytenoid arthritis which is unlikely to suppurate.

Acute traumatic perichondritis may be occasioned by blows, wounds, throttling, bruising by high collars, the impaction of foreign bodies in the larynx or esophagus, or the unskilful passage of intubation tubes and esophageal bougies. A prolonged recumbent position especially in old and poorly nourished persons, occasionally results in decubitus by pressure of the cricoid cartilage upon the spinal column. The aged are also subject to a sort of spontaneous perichondritis in connection with calcareous changes in the cartilages.

Secondary perichondritis is more frequent. It occurs in an acute form during the course of septic and continued fevers, especially typhoid fever, smallpox, and diphtheria. It may either be preceded by ulceration, through which infection by pyogenic germs occurs, or it may represent a metastasis of the specific infecting organism. Typhoid bacilli are usually found in the necrotic cartilage in typhoid-fever cases, and it has been shown that they alone are capable of producing suppuration, but it is probable that they act usually in conjunction with pyococci.

The most frequent of all forms of perichondritis are those which are secondary to syphilis, tuberculosis, and carcinoma. Though often commencing in an acute manner they usually eventuate in a chronic process. The *Spirochæta pallida*, leading to the infiltration of syphilis, may attack directly the cartilages and perichondrium, and tuberculous arthritis analogous to the white swellings of the larger joints is a possibility, but usually ulceration of the soft parts serves as an intermediate cause, providing an opening through which infection by pyococci takes place.

PATHOLOGY.—In acute perichondritis there occurs a purulent infiltration of the perichondrium whereby it is separated from the underlying cartilage; and this, involving also the overlying soft parts, constitutes a perichondritic abscess or swelling, which according to the layer affected may project externally or into the lumen of the larynx. Necrosis of the underlying cartilage and exfoliation of small or large sloughs may eventually ensue. If the perichondrium and part of the cartilage remain, partial reproduction or else fibrous substitution may take place. A fistula is apt to persist. In so-called rheumatic cases and in syphilis under vigorous antisyphilitic treatment the exudation may proceed to absorption without suppuration. In typhoid fever and other cases extensive ulceration may follow the rupture of the abscess. Edema is a prominent feature of tuberculous perichondritis as well as of the syphilitic form of the disease. It helps to impede the movements of the larynx, and is liable to culminate suddenly in dangerous occlusion of the rima glottidis. The cricoid cartilage is the one attacked in about two-thirds of the cases, and the arytenoid comes next in order. In the former case the abscess points either into the lumen of the larynx or into the esophagus or pyriform sinus; in the latter the opening is seen near the position of the vocal process. Instead of one there may be several openings, all discharging pus. When the thyroid is affected, the involvement is more often unilateral and internal. Extensive necrosis of this cartilage is less likely to occur because of a richer blood supply. The epiglottis being a fibrocartilage is affected only by an ulcerative action. The tracheal rings sometimes become involved.

SYMPTOMS.—The acute type is ushered in by febrile symptoms and local pain or discomfort, followed by dysphagia, dyspnea; tenderness on pressure, and impairment of the voice, all varying in degree according to the cartilage and surface involved.

Seated in the *cricoid*, when the sides of the cartilage are affected, the swelling projects into the lumen of the larynx, thus obstructing respiration; when the rear plate is involved the tumefaction is toward the esophagus, then impeding deglutition. When the *arytenoid* is the seat of the disease it is liable to impede both respiration and deglutition. The cricoarytenoid joint becomes ankylosed and the vocal cord fixed, hoarseness of the voice resulting. Fixation of the cord in the median line would contribute to dyspnea.

Affection of the *thyroid* on the inner face leads to dyspnea but may or may not impair the voice. The most dangerous dyspnea results from collapse of the laryngeal framework after the expulsion of the greater part of the cricoid cartilage. Wherever seated, the pus is liable to burrow, discharging through fistulæ which may open either within the throat or upon the neck. The sequestrum serves to maintain suppuration until exfoliation occurs, a process which unassisted may require months or years, depending upon the size and position of the sequestrum.

In *typhoid fever* the onset is usually rapid, although slight hoarseness and dysphagia may have been perceived for some days. The suffocative attacks once commenced recur at shorter intervals and are more and more terrible until tracheotomy becomes necessary to prevent a fatal termination.

Laryngeal Image.—Arytenoid perichondritis causes a unilateral pyriform swelling, or if bilateral the tumefaction is not exactly symmetrical. There is immobility of the cartilage and the edema extends along the aryepiglottic fold. The necrotic cartilage will sometimes be seen to project from the abscess opening. When the inner surface of one side of the cricoid cartilage is affected there will be a bulging beneath the vocal cord, perhaps extending around the posterior laryngeal wall, and this condition is often combined with tumefaction of the arytenoid. A swelling in the pyriform sinus or in the laryngopharynx indicates involvement of the outer surface of the cricoid. An abscess under the anterior commissure indicates a perichondritis of the inner surface of one or both plates of the thyroid cartilage, in which position tuberculous ulceration is the usual cause.

DIAGNOSIS.—The tumefaction of perichondritis is unilateral or not equally bilateral, and is irregular in outline. In edema of the larynx and acute phlegmonous laryngitis the puffiness of the parts is usually symmetrical, and in laryngeal diphtheria there is an exudate.

In chronic cases, especially those secondary to syphilis, tuberculosis, and carcinoma, the perichondritis is apt to be obscured by the infiltration and ulceration incident to the primary disease. A fistula discharging pus, a swelling corresponding in location to the cartilages affected, and ankylosis of the

cricoarytenoid joint, are indications of perichondritis. Ankylosis resulting in a fixed position of the vocal cord is distinguished by arytenoid swelling from abductor paralysis of the cord. The presence of swelling and the absence of "falling in" of the arytenoid distinguish it from complete recurrent-nerve paralysis. Additional details are given in the article on "Cricoarytenoid."

Prognosis.—In acute cases the danger to life from dyspnea may require a prompt tracheotomy, without which the gravity cannot be overestimated. In typhoid-fever cases, when necrosis of cartilage ensues, the mortality is very high. The prognosis is favorable in traumatic, rheumatic, and syphilitic cases provided the nature of the disease is recognized and appropriate treatment instituted. Among these there are many mild cases in which recovery takes place without difficulty, and in the majority of severe ones the patients survive, but with more or less damage to the larynx. The disease may run a course of several years, for exfoliation is a slow process, and meanwhile the patient is liable to exhaustion by cough, dysphagia, and general distress, so that surgical assistance may improve his chances. Naturally, the tuberculous and carcinomatous conditions are most unfavorable.

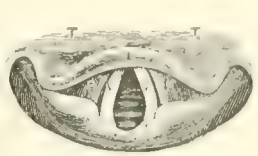


Fig. 3687.—Showing the Position of the Vocal Bands during Passive Inhalation.

Fig. 3688.—Showing the Position of the Vocal Bands during Forced Inhalation.

Fig. 3689.—Showing the Position of the Vocal Bands during Phonation

Figs. 3687, 3688, and 3689.—*T*, Tongue; *L*, epiglottis; *P, P*, ventricular bands; *W, W*, cartilages of Wrisberg; *S, S*, cartilages of Santorini; *V, V*, vocal bands; *WP*, wind pipe or trachea; *B* bifurcation of the trachea. (From Lennox Browne and E. Selenke.)

Treatment.—In the very early stage of acute perichondritis, cold in the form of ice slowly swallowed and cold application for a brief period over the larynx externally, supplemented by an ichthyol ointment, tends to abort the disease. Hot sedative vapors and steam inhalants allay the pain, but are indicated only when the tumefaction is insufficient to cause dyspnea and after tracheotomy has been performed, because, while allaying pain, they are liable to intensify the dyspnea by increasing the swelling. Alkaline and emollient sprays serve to clear the throat of mucus. Cocaine one per cent. in adrenalin solution, 1 : 10,000 or less, is of value in causing temporary retraction of the swelling, but its powers are limited. An accessible abscess may be opened by a laryngeal lancet, but if the pus collection is large and points within the larynx, care should be taken to evacuate it slowly unless a tracheotomy tube is in place. Measures which are appropriate in the treatment of the primary diseases are serviceable for secondary perichondritis, *e. g.* potassium iodide, salvarsan, and mercury in syphilitic cases. On the appearance of severe dyspnea a low tracheotomy should be promptly performed. Delay involves the risk of pulmonary edema. After exfoliation and cicatrization, the resulting stenosis of the larynx will require dilatation in the same manner as syphilitic stenosis of the larynx, or else the tracheotomy tube will need to be indefinitely retained.

W. E. Casselberry.

Larynx, Physiology of the.—The larynx is that portion of the respiratory tract which is situated in the median line of the neck between the trachea and the pharynx. It may be regarded merely as a prolongation upward of the trachea, with such modifications of structure as are required for the performance of its various specialized functions. A comparative study of the larynges of animals indicates that the extent of the modifications of structure is proportional to the variety of the specialized functions. Following this law, the structure of the human larynx differs very considerably from that of the trachea, and its mechanism is interesting and complex (Figs. 3687, 3688, and 3689). The framework of the trachea is composed of incomplete cartilaginous rings, bearing a close resemblance to one another, and bound together by fibromuscular tissue, and while the cartilages of the larynx are for the most part irregular in shape, a scheme somewhat similar to that of the trachea is carried into its structure.

The cricoid, the first cartilage above the trachea, differs from all the others in that it is complete throughout its entire circumference, and it thus serves as a firm base for the superstructure of the larynx. The thyroid, like the cartilages of the trachea, is open posteriorly, thus giving room for the two arytenoids which articulate with the elevated posterior portion of the cricoid. The hyoid bone, which is closely related to the larynx, is also open posteriorly to make room for the anterior portion of the pharynx. The other cartilages of the larynx are the cornicula laryngis, the cuneiform cartilages, and the epiglottis. These cartilages form the framework of the larynx, and they are so jointed and connected by ligaments as

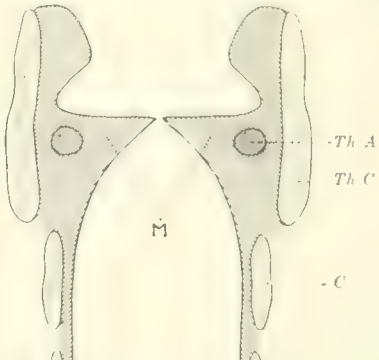


Fig. 3690.—*Th A*, Thyroarytenoid muscle; *Th C*, thyroid cartilage; *C*, cricoid cartilage; *M*, vocal shelves.

to be freely movable when acted upon by their respective muscles. The object of this motion is threefold: (1) to control the breath, (2) to bring into position the bands or shelves the vibrations of which cause the sound of which voice is made, and (3) to assist in the production of voice and speech. The three highly specialized functions of the larynx, therefore, may be described under the following heads: (1) Respiration; (2) Phonation; (3) Articulation.

Respiration.—The respiratory function of the larynx is an important one and it includes more than would appear at first thought. Air could be made to pass to and from the lungs without the intervention of this complicated structure and therefore the act of breathing may be regarded as a purely incidental function of the larynx. It was necessary to place somewhere in

the respiratory tract a structure that would not only furnish a free passageway for the breath, but would also, at the same time, serve other important purposes. Of these purposes phonation, to be described later, is the most important, and the act of phonation requires some kind of temporary obstruction in the air channel, such as is provided by the two muscular bands that run from the thyroid to the arytenoid cartilages. Moreover, these bands must obstruct respiration as little as possible and only at those times when the obstruction is necessary for the phonatory act. Provision is therefore made for their removal from the lumen of the larynx when not required for this purpose, and this is accomplished by the contraction of the posterior cricoarytenoid or so-called respiratory muscles. These abductor muscles are supplied by the external branch of the superior laryngeal nerve, and so important are their functions in maintaining the patency of the larynx for respiratory purposes, contracting as they do for every act of inspiration (about eighteen times a minute), that they seem to be endowed with greater strength and they are less susceptible to disease than the other muscles of the larynx. Life itself depends upon their health and tone (Figs. 3687, 3688, and 3689). But the larynx has another important function that should be described under this head, and that is the closure of its upper portion during the vigorous muscular acts which are performed by the hands and arms, and also during the acts of defecation, coughing, laughing, etc.

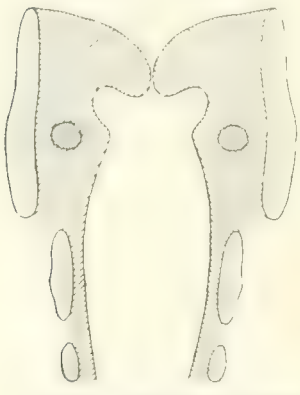


Fig. 3691.—Shows the Valvular Action of the Ventricular Bands. *a*, Ventricular bands.

This strong closure of the upper portion of the larynx takes place above the vocal bands, and not so much in the glottis as has been supposed. The glottis, it may be remarked, is merely the aperture formed by the vocal bands, the vocal processes, and a portion of the transverse arytenoid muscle (Fig. 3687). The vocal bands are too slender and delicate to endure the strain that would be put upon them by this action, and their structure, shape, and position, when the glottis is closed, render them incapable of resisting much pressure of the breath from below. They are not in reality bands at all in their shape and structure, but if a cross-section of them were made (Fig. 3690), they would be found to be somewhat wedge shaped with the head of the wedge looking upward and the apex downward; their inner edges contribute, during tone production, to the formation of the vibrating portion of the glottis, and their inner surfaces gradually taper downward along either side of the larynx. Other names have been suggested for them such as cushions or shelves, and the latter is the one to be preferred because it more accurately describes their shape and functions. It will be observed that when the glottis is closed the gradual tapering of the vocal shelves downward makes the lower portion of the larynx somewhat cone shaped with the apex pointing upward, and that this approach to the glottis adapts it not for checking but rather for favoring the egress of air (see Fig. 3690). When the breath is forcibly held for any purposes whatsoever, the true glottis is not closed at all, but the pseudoglottis is closed by the approximation of the ventricular bands, and the ventricles, the shape of which is so well adapted to this purpose, become inflated and unite to form a more or less perfect valve capable of resisting great pressure with a minimum amount of effort (see Fig. 3691). The upper surface of the closed glottis to a lesser degree acts like a valve in checking the ingress of air. This function, however, is not so important, for the amount of air taken into the lungs is controlled largely by the great respiratory muscles of the thorax.

In addition to this valvular action the upper portion of the larynx closes at times in much the same way as do the sphincters in other parts of the body. It was formerly supposed that the epiglottis, serving as a lid to the larynx, was the only means of preventing the food from entering this cavity during deglutition, but, in refutation of this theory, it was found that the entire removal of the epiglottis, either by operative procedure or by disease, in no respect interferes with deglutition. It appears, therefore, that nature has not entrusted to the epiglottis alone the important function of guarding the gateway to the lungs against the intrusion of foreign substances, but, in addition to and immediately preceding the falling of the epiglottis over the larynx during deglutition, there is a complete closure of the entire upper part of the larynx. This is effected by the approximation of the ventricular bands, the upper part of the arytenoid cartilages, the aryepiglottic folds, and the lower portion, or so-called cushion, of the epiglottis. The muscles causing this closure of the upper portion of the larynx have been called the sphincters of the larynx. They are the thyroaryepiglotticus, the thyroarytenoideus externus, and the arytenoideus posticus.

In the act of deglutition the sphincter muscles contract, and over the closed gateway of the larynx the epiglottis falls of its own weight, or rather as a result of the relaxation of the hyoepiglottic ligament, incident upon the elevation of the larynx. The theory formerly held, that the epiglottis is drawn over the larynx by muscular action, is rendered improbable by the fact that the muscular fibers running from the epiglottis to the hyoid bone, in the human subject, are very small and but slightly developed.

Phonation.—The chief purpose of the larynx and the one to which it is especially adapted is phonation, but this function is so closely related to the action of certain other organs, notably those of respiration and articulation, that it will be necessary to take these into account also, at least to some extent.

Voice, as I have defined it elsewhere, is the result of a moving column of breath, set in vibration by its own impact with the vocal shelves and re-enforced by its diffusion through the various resonant chambers into the surrounding atmosphere, and therefore it follows that the act of phonation is the process by which the column of breath is formed, set in vibration, and diffused, and a description of this process must include the necessary respiratory movements, and at least a reference to the resonant chambers, as well as a description of the action of the larynx itself.

The respiratory movements of phonation are different from those of ordinary breathing. The one is active, and the other is passive. The breathing of phonation supplies the system with oxygen, and carries off the effete products, in the same manner as does ordinary breathing, but it does this only incidentally, its special function being to cause impaction of air upon the vocal shelves, which impaction causes the necessary vibrations. Moreover, the character of this impaction of the column of breath upon the vocal shelves is an important factor in the regulation of their vibrations. It has been shown by actual demonstration that the rapidity of the vibratory excursions of the vocal shelves is increased and the pitch of the voice heightened by an increase in the rate of motion of the column of breath. This is true, in part at least, because the increase in the rate of motion is attended by an increase of expiratory effort, and a corresponding increase of pressure within the

column of breath; the tracheal tube being somewhat elastic, this pressure tends to enlarge the column of breath in the trachea, and as this is forced through the smaller opening of the cricoid cartilage it carries its anterior portion upward toward the thyroid, and its posterior portion downward, thus increasing the distance between the anterior and posterior attachments, and becoming a direct longitudinal tensor of the vocal shelves. On the other hand, if this tendency of the column of breath to render the vocal shelves tense during its rapid and forcible movement is resisted by the contraction of the internal thyroarytenoid muscles, the result will be a wider vibratory excursion of the vocal shelves and a greater intensity or loudness of voice. In this way the column of breath becomes an important factor in regulating both the pitch and the intensity of the voice.

The respiratory movements of phonation, therefore, are definite and active. The base of the column of breath rests upon the diaphragm, and it is surrounded laterally by the walls of the thorax with their enveloping ligaments and muscles. The muscles may be divided into two sets, those which elevate the ribs and those which depress them, the former tending to enlarge the thoracic cavity, and the latter to diminish its capacity. It will be observed that the depressor muscles exert a force which is directly opposed to the action of the levator muscles, and it is by means of these two opposing forces that the column of breath may be controlled with the necessary accuracy, and that the requisite tension may be given to the drum-like walls of the thorax for the purpose of giving resonance to the voice (Fig. 3692). The column of breath is, therefore, compressed and its rate of motion through the glottis regulated with great precision.

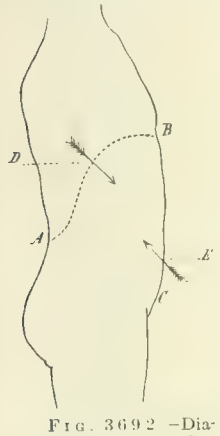


Fig. 3692.—Diagram showing the Opposing action of the Diaphragm and Abdominal Muscles. *A–B*, Diaphragm; *B C*, abdominal muscles; *D*, direction in which the diaphragm acts; *E*, direction in which the abdominal muscles act.

The tracheal, pharyngeal, oral, and nasal cavities are also resonators, and serve to re-enforce the tones produced by the vibration of the vocal shelves.

The framework of the larynx, as already mentioned, is composed of irregularly shaped cartilages articulating at the several points of contact by means of freely movable joints. The muscles having their attachments only to these cartilages, and whose function it is to assist in the regulation of their relative positions, are called intrinsic muscles; those running from the cartilages to various points without the larynx are called extrinsic muscles. The extrinsic laryngeal muscles, like the thoracic muscles, may be divided into two sets, according as they elevate or depress the larynx. The levator muscles are the palatopharyngei, the stylopharyngei, digastric, stylohyoid, geniohyoid, and hyoglossi. The depressor muscles are the omohyoid, sternohyoid, and sternothyroid. The function of the extrinsic muscles is (1) to determine the position of the larynx in its relation to the adjacent structures, and (2) to determine the position of certain important parts of the larynx in their relation to other parts. The position of the larynx in its relation to adjacent structures varies with the variation in the quality and pitch of the voice, and the importance of a correct position cannot be overestimated. When both the levator and depressor muscles are brought into action, the larynx becomes fixed, and an additional result of these two forces (as will be observed in Fig. 3693) is to draw the larynx backward against the spine. If these two sets of muscles are strongly contracted, the posterior surface of the plate of the cricoid cartilage will be fixed against the anterior surface of the fifth cervical vertebra, and thus vocal resonance may be transmitted through the spinal column to all parts of the body.

Moreover, with the cricoid cartilage in contact with the fifth cervical vertebra, it is evident that if the force of the contraction of the depressor muscles is greater than that of the levator, the result will be a forward tilting of the thyroid upon the cricoid cartilage and a stretching of the vocal shelves. In this way it is altogether probable that the extrinsic muscles of the larynx may assist the intrinsic muscles in rendering the vocal shelves tense, at least during the production of tones of unusually high pitch. Opinions differ, however, with reference to this important point, some claiming that the extrinsic muscles are the sole cord stretchers in voice production, others that this function comes entirely within the province of the intrinsic muscles. While this is one of the many questions with reference to the physiology of the voice that are difficult of demonstration, it is quite probable that there may be some truth in both theories and that unusual results in voice production may be attained by a judicious combination of both the extrinsic and the intrinsic muscles in the control of the vocal shelves. The

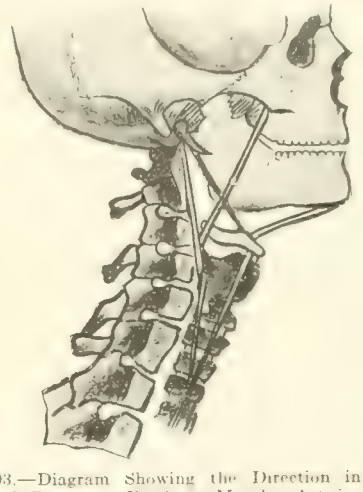


Fig. 3693.—Diagram Showing the Direction in which the Levator and Depressor Extrinsic Muscles Act in Holding the Larynx Against the Spine. (From Howard.)

function of the larynx in phonation is to furnish and control the shelves, the vibration of which is the first cause of the sound of which voice is made. These shelves are merely reduplications or folds of the lining membrane of the larynx reflected over the thyroarytenoid or so-called vocal muscles, the lining membrane of that portion of the shelves which forms the rima glottidis having been transformed, by the exercise of its function, into white fibrous tissue. The various changes in the laryngeal tones of the voice depend upon certain changes in the physical condition of the vocal shelves. The laws governing the vibrations of the vocal shelves are somewhat similar to those governing the vibrations of strings, the three physical changes in them which govern the pitch of the tone being changes in length, weight, and tension. The length and weight of the vocal shelves vary somewhat in different larynges. Those in the larynx of the male, for instance, are longer and heavier than those in the larynx of the female, and the pitch is correspondingly lower. The length of the vibratory portion of the shelves, however, may be changed in each larynx by certain changes in the action of its muscles. This phenomenon may be observed by

means of the laryngoscope. When a tone of high pitch is produced, the vocal processes of the arytenoid cartilages appear to meet in the middle line, and the posterior edges of the glottis are held in apposition. The same conditions seem to obtain also with reference to the anterior edges (although in many cases, especially during the emission of low tones, they are partially hidden from view), and thus the vibrations may be limited to scarcely more than the middle third of the glottis (Figs. 3687, 3688 and 3689). The shortening of the glottis posteriorly is brought about by a vigorous contraction of the arytenoid and the lateral cricoarytenoid muscles, causing the vocal processes to come into close apposition and possibly to overlap slightly. At the same time the thyroid tilting muscles, the cricothyroid and the sternothyroid, serve to stretch further the vocal shelves; and the latter muscles when the levator laryngei muscles are in action serve also to compress the alæ of the thyroid cartilage, which compression would naturally bring into closer apposition, not only the posterior but also the anterior edges of the glottis. Moreover, it has been shown by Willis that the approximation of the anterior portion of the cricoid cartilage to the thyroid, which is made evident by placing the finger in this region during the emission of a high tone, has a tendency to push the tapering portions of the vocal shelves upward, and to bring into close contact the anterior edges of the glottis. This theory of the regulation of the glottis by forced muscular action during the production of the higher notes of the falsetto voice is demonstrated not only by the laryngoscope, but also by the conscious increase of the muscular effort required for the production of these tones. The mechanism that shortens the vibratory portions of the shelves, at the same time diminishes the width of their vibrating surfaces and increases their tension. As the internal thyroarytenoid or vocal muscles contract more and more when their attachments are fixed both anteriorly and posteriorly, as above described, the result is a lateral diminution of the vibrating portions of the vocal shelves. When these vocal muscles are contracted to their utmost, only the very thin edges of the shelves are available for vibration. The internal thyroarytenoid muscles throw out numerous small muscular fibers into the bodies of the shelves, the function of which is to regulate the extent of the lateral vibratory surfaces of the shelves, and probably also to assist in regulating the longitudinal vibratory surfaces.

Articulation.—Thus far we have considered the larynx in its relation to tone production. It must be borne in mind that the tone produced by the laryngeal mechanism above described differs from what we hear as the human voice, but this difference is not apparent because it is impossible for the human ear to differentiate the two. If we could make a section of the larynx containing the vocal shelves as they actually exist, and if by some mechanical measures we could reproduce their actual movements of adduction during tone production, and also at the same time set them into vibration by artificial means, we should then be able to get the primary tonal element of the voice. The vocal shelves hold the same relation to the organs of voice that the strings of a violin hold to the instrument itself. The tones that we hear from the violin are the result not alone of the vibrations of the strings, but of the effect that these vibrations make upon the whole instrument, and so the human voice is the result of vibrations originating at the vocal shelves and modified not only by the larynx itself, but, to some extent at least, by the entire organism. The human voice, therefore, is the result of various complex conditions. People differ, as do violins, both in their composition and in their structure, and as the tones of violins differ, so for the same reason, and to a greater extent, do voices differ one from the other. The simplest tone of the voice reaches the ear as one of the so-called vowel sounds, or as some modification of them. The vowel sounds, therefore, are the purely vocal elements of speech and song. The tone originating in the glottis immediately begins to take on the quality of one of the six physiological vowel sounds, or some combination of them, according to the adjustment of those portions of the respiratory tract which are situated above the glottis. Concerning the mechanism of the production of the vowel sounds there have been numerous theories. It has been generally conceded that the vowel sounds are the results of various combinations of the laryngeal with certain other so-called resonance tones. Helmholtz claimed that the vocal apparatus resembles the pipe organ, the vocal shelves corresponding to the reeds, and the pharyngeal and oral cavities to the pipes; and that, as the reeds of the organ vibrate in wholes for the fundamental tone, and halves, thirds, etc., for the harmonics (overtones), each of the various pipes of the organ selecting the particular harmonic to which its vibratory caliber corresponds, and thus determining the characteristic note of the organ, so the vocal shelves vibrate in wholes for the fundamental tone, in halves, thirds, etc., for the harmonics, and the pharyngeal and oral cavities, being flexible and capable of many variations in shape and size, adjust themselves to correspond to the particular overtone the combination of which with the fundamental tone is characteristic of the vowel sound to be produced.

Up to the present time this has been the theory accepted by the majority of writers and teachers of the subject, but there appear to be decided objections to it, and it does not accord with more recent investigations. Notwithstanding the great flexibility of the laryngeal, pharyngeal, and oral cavities it is probably impossible for them to be adjusted in size and shape to meet the requirements of Helmholtz's harmonic or overtone theory.

Antedating the theory of Helmholtz, and opposing it in some respects, is the theory of Willis. He claims that the resonance tones are independent of the laryngeal tones in respect to pitch. This theory was strengthened by the later experiments of Hermann and others, and it seems about to be verified by the extensive investigations of Prof. E. W. Scripture, of Columbia University.

These investigations are being made with care and accuracy and they cannot fail to be of great scientific value. By means of complicated machinery, enlarged tracings of the curves of speech are taken from gramophone plates, and the character of the vowel sounds is computed by accurate measurements of these tracings. The result will probably change some of the hitherto accepted views concerning the elements of speech and clear up disputed points with reference to voice production. The tracings appear to show that the glottic tone is the result not of actual vibrations of the vocal shelves, but of a succession of respiratory puffs through the glottic chink, and that the resonance tones are the result of free, in contradistinction to forced, vibrations in the cavities above and below the glottis; or, in other words, that the resonance tones are the result of vibrations set up in these cavities by a more or less irregular succession of blows from the vocal shelves.

These investigations also show that the resonance tones are composed of a series of tones that may have a different pitch the one from the other, and that the pitch of the resonance tones does not necessarily change with that of the glottic tone, and therefore that the resonance tones cannot be overtones of the glottic tone, as is commonly supposed. They show, also, that the vowel sounds as they appear in good speech are of almost constantly varying pitch.

This analytical method of studying the curves of speech is only in its infancy, but it is so distinctly

scientific in its nature as to warrant this brief description of it, and the interesting results thus far obtained. Whatever may be the truth with reference to these disputed points, we know that the vowel sounds are the result of the proper blending of the glottic with the resonance tones. The principal resonance chambers are the tracheal, upper laryngeal, pharyngeal, oral, and nasal cavities. With the exception of the tracheal and nasal cavities these resonance chambers are flexible and capable of numerous changes not only in their size and shape, but also in the muscular rigidity of their walls, and together they form what have been called the moulds of speech, each vowel sound having its individual resonance mould, which varies more or less continuously in respect both to its shape and its size and to the rigidity of its walls.

Vowels.—It is the manipulation of the mould that determines the character of each vowel sound and that distinguishes one vowel sound from another. The resonance mould may be shortened more than an inch by the elevation of the larynx and the retraction of the lips. Several of its diameters may also be shortened by the contraction of the lateral walls of the larynx and pharynx, and by the various movements of the epiglottis, velum palati, tongue, lower jaw, and lips. Some of these parts have points of actual contact, thus dividing the mould into several smaller and more or less well-defined compartments with or without communicating passageways. Each compartment has its individual vibrations, and it is the various admixtures of the resultant tones combined with the glottic tone that produce the characteristic elements of speech.

For the sound of *E* in eve, the mould is shortened by the elevation of the larynx and the retraction of the lips, and it is flattened and narrowed in the linguopalatal region by the elevation of the tongue and its contact with the lateral molar teeth. Its diameters are also shortened in the region of the ventricular bands and the aryepiglottic folds.

The sound of *A* in ate, requires a somewhat longer mould and a larger labial and linguopalatal aperture for the beginning of the sound, and for the ending of the sound it approximates the mould for the sound of *E*.

The sound of *Ah*, or *A*, in father, requires a still longer mould and a wider aperture in the labial and linguopalatal regions.

The sound of *Aw*, as in awe, requires a still longer mould.

In the sound of *O* in old, the long diameter of the mould is considerably increased by lowering the larynx and protruding the lips. The linguopalatal, pharyngeal, and laryngeal diameters are also considerably increased.

In the sound of *OO* in boot, the lips are somewhat farther protruded and the labial aperture diminished in size.

It will be observed that for the *six* physiological vowel sounds, named in their order as above, the resonance mould grows progressively longer beginning with *E* as its shortest and ending with *OO* as its longest diameters.

It must be apparent that the above is merely a brief outline of some of the important adjustments of the vowel moulds, and that a precise description of them, for even a single vowel, would be impossible, because they differ not only in different individuals, but in the same individual during different intellectual and emotional states of mind.

Consonants.—There are twenty-three so-called consonant sounds in the English language, and they may be classified, as in the accompanying table, first, according to the particular parts of the resonance mould actively employed in their production (Fig. 3694), and secondly, according to the character of the sounds (see table). It has been observed that the sounds of the five consonants, *P*, *B*, *M*, *Wh*, and *W*, are made by the lips, and, therefore, they have been classified as labials, and that the sounds of *B*, *W*, and *M* are voiced sounds while those of *P* and *Wh* are voiceless or merely breath sounds. The sounds of *F* and *V* are made with the lower lip and upper teeth and are named labiodentals, the first one being a voiceless,

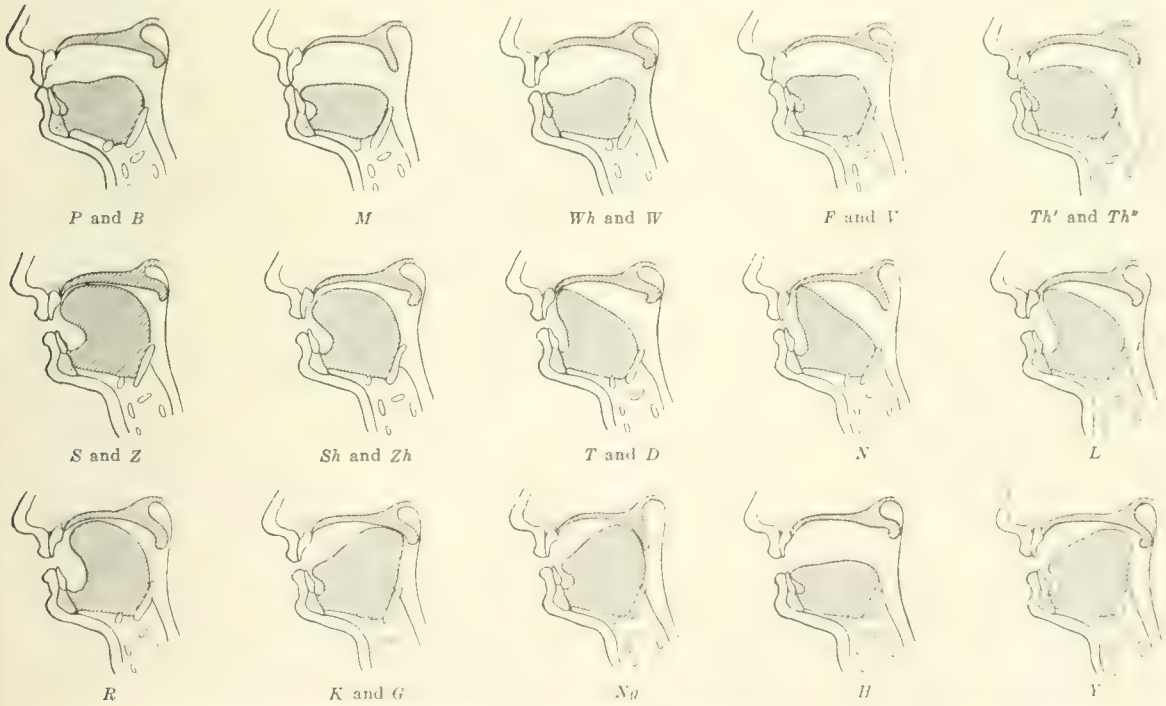


FIG. 3694.—Showing Approximately the Position of the Organs in the Articulation of the English Consonant Sounds.

and the second a voiced sound. The sound of *Th*, as in think, and *Th*, as in thou, are made with the tip of the tongue and the upper teeth, and are called linguodentals, the first one being voiceless, and the second voiced.

PHYSIOLOGICAL ALPHABET.

Consonants.

	Voiceless oral	Voiced oral	Voiced nasal	
Labials	P	B	M	Paul Brown made white
	Wh	W		wax.
Labiodentals....	F	V	.	Full voice.
Linguodentals .	Th′	Th″	.	Think thou.
Anterior linguo-palatals.	S	Z	.	Some zealous sheep lei-
	Sh	Zh	.	surely took down nine
	T	D	N	large rails.
		L		
		R		
Posterior linguo-palatals.	K	G	Ng	Can girls bring home yeast?
	H	Y		

Vowels.

a	ā	l-	o	ō	ld	ār	f ār e
à	ā	t	ŏ	ō	n	ăr	f ăr
a	a	lms	o͞o	o͞o	ze	ēr	h ēr e
a	a	ll	o͝o	l o͝o	k	ĕr	h ĕr
å	ă	sk	ĭ	ī	t		
e	ē	ve	ŭ	ū	p		
ĕ	ĕ	lk					

Coalescents.

o͞i	f o͞i e
o͡ŏr	f o͡ŏr
o͞or	p o͞or
u͡r	p u͡r r

The sounds of *S*, *Z*, *Sh*, *Zh*, *T*, *D*, *N*, *L*, and *R* are made by the tongue and the anterior portion of the hard palate, and are called anterior linguopalatals, the *S*, *Sh*, and *T* being voiceless, and the *Z*, *Zh*, *D*, *N*, *L*, and *R* being voiced.

The sounds of *K*, *G*, *Ng*, *H*, and *Y* are made by the dorsum of the tongue and the velum palati, and are called posterior linguopalatals, the *K* and *H* being voiceless, and the *G*, *Ng*, and *Y* being voiced. In considering the elements of speech it must be borne in mind that the names of the letters of the alphabet do not always indicate the sounds of the letters. For instance, the letter *B* is composed of two elementary sounds, *B* and *E*; *G* is composed of three elementary sounds —*D*, *Zh*, and *E*; and the letter *W* is composed of six elementary sounds—*Dŭblyo͞o*. Hence it has been found necessary to construct an alphabet of sounds. This was done in 1827 by Dr. Neil Arnott, and his alphabet was modified, during the last decade, by Dr. John Wyllie, of Edinburgh, who gave it the name of physiological alphabet. It is reproduced here with some important additions and alterations. This revised physiological alphabet contains forty-four sounds, and it will be found useful as a standard for comparison in cases of marked defective speech.

Registers of the Voice.—The singing voice has a certain range of pitch that seems to be adapted to a fixed adjustment of the larynx, and in order to increase the range of pitch it is necessary to make a somewhat different adjustment. These changes are accomplished chiefly by the action of the extrinsic muscles, and in going from one adjustment to another it has seemed to be necessary to make a slight break in the voice. This fact has given rise to the so-called upper, lower, and middle registers of the voice, each register having its own particular adjustment of the larynx, and being separated by a more or less marked interruption of the tone, consequent upon the readjustment of the laryngeal mechanism. One great test of the excellence of a vocal method seems to be its power to enable the singer to make the readjustments for the different registers with the least possible interruption. If these interruptions or breaks, as they are named, could be eliminated entirely there would be no necessity for the use of the term registers, and this is the position taken by many of the best vocalists and physiologists. It seems entirely within the bounds of reason to suppose that, in the thoroughly trained larynx, the various adjustments of its parts, complicated though they may be, could be accomplished with sufficient smoothness to enable the singer to go from the lowest to the highest pitch with no appreciable break, and that there should therefore be but one vocal register.

The Falsetto Voice.—The thin upper tones of the voice, containing no appreciable resonance from the chest or other large resonance chambers, have been named the falsetto or false voice, in contradistinction to the well-rounded voice resulting from a combination of the laryngeal with all the various resonance tones. The name for this quality of voice is unfortunate, because it has its place both in singing and in speaking, and it differs from the so-called true voice only in the fact that it contains fewer of the resonance tones.

Whispering.—Another quality of voice that must be considered is that of whispering. It is also the result of a combination of laryngeal with resonance vibrations. But the laryngeal tones arise from a free efflux of breath through a comparatively open glottis, and it is quite probable that the ventricular bands also take some part in this fricative sound. The laryngeal vibrations, however, are not of such a nature as to set up additional vibrations in all the resonance chambers. The whispering voice, therefore, is the result of fricative laryngeal vibrations re-enforced by imperfect resonance vibrations.

Defective Speech.—In the majority of cases the immediate cause of defective speech is a faulty construction of the moulds of speech. The remote causes are often more difficult to determine. In their origin they are either central or peripheral, and cases of long standing are both central and peripheral. A cleft palate, for instance, always results in defective speech, and the primary cause is peripheral, but the effort to adapt the faulty organs to the requirements of speech develops a defective action in the motor and auditory centers of the brain which marks the case as coming under the head of both a central and a peripheral affection. The central affection, of course, is purely functional, but it is often exceedingly difficult to eradicate. The patient must be taught to make correct moulds, and it has been found that, when the peripheral organs are intact, a frequent repetition of this process, continued for a sufficiently long time, will correct the faulty cerebral action and improve the habits of speech.

Stammering.—A somewhat less frequent, though more distressing, affection of speech is stammering. Its primary cause may also exist in the peripheral organs, but it is more often of cerebral origin. So complicated are the nervous processes of speech that the only wonder is that the disorder is not more common. The motor processes of normal speech are for the most part automatic, and a slight disturbance in any part of them may for the time being completely destroy their automatic action. This leads to a kind of mental confusion which is incompatible with normal speech and which results in a condition of partial or complete auditory amnesia. The stammerer cannot say the word or a portion of the word because in his mental confusion he cannot on the instant recall its complete auditory image. No two cases of stammering are alike, and therefore the scientific treatment of the affection should include a knowledge of the various methods for ascertaining the abnormal mental and physical conditions giving rise to the affection. In other words, as in faulty machinery of any kind, the weak points should be found and the remedy applied directly to them.

The normal automatic action of the organs of

speech must be restored, and this can be accomplished only by slow stages through the intermediation of the development of volitional action. The patient must first learn to recognize, through the auditory and perceptive centers of the brain, the nature of normal speech, and then he must learn to recognize the sensations attendant upon its production.

G. Hudson Makuen.

Larynx, Stenosis of the.—Stenosis of the larynx as it is understood clinically means a narrowing of the lumen of that structure. The symptoms vary from a slight difficulty in breathing to actual strangling. Often there is no impairment of the voice.

Cases of stenosis of the larynx fall into four groups, as follows: (1) Stenosis due to faulty development. (2) Stenosis due to infection. (3) Stenosis due to papilloma. (4) Stenosis due to scar tissue. Groups three and four furnish the majority of the cases.

Diagnosis.—The diagnosis of the cause of the lesion must be made by inspection. The larynx can be examined indirectly by the laryngeal mirror or directly by means of a speculum. The patterns of speculum in common use are the autoscope of Brünings, the tubular speculum of Jackson, and the adjustable speculum of the writer. In many instances the history of the case gives a clue to the diagnosis, and so before speaking of the various methods of examining the larynx a little may be said profitably on this part of the subject. A frequent and typical history runs in the following manner. A child is presented of whom the parents say that since an attack of diphtheria which required intubation it has had gradually increasing difficulty in breathing. Often on inquiry, it is found also that it was impossible to leave the intubation tube out safely until after some weeks. Such a case is practically sure to show on examination a gluing together of the vocal cords, generally anteriorly, or a subglottic swelling, or both conditions. A second typical history is the following: An apparently healthy child begins to lose his voice and to talk in a whisper. In time he has trouble in breathing. With the onset of a cold this may become alarming. Nine times out of ten this is a case of papilloma of the larynx. Again, given a well-nourished adult, below the cancer age, who has signs of laryngeal narrowing, and admits syphilis, there is a very strong probability that he is suffering from narrowing of the larynx due to the contraction of scar tissue left by a previous syphilitis chondritis. Finally, if a baby is presented with the history that since birth she has never breathed well the probable diagnosis lies between adenoids, an enlarged thymus, and a congenital web between the vocal cords. A probable diagnosis of the cause of the laryngeal stenosis in many instances, therefore, can be made from the history. The actual diagnosis, as was said at the beginning, must be made by sight, that is by using the laryngeal mirror, the indirect method, or by direct inspection of the larynx through a speculum, or by the speculum reinforced by suspension—suspension laryngoscopy. Children are best examined by the direct method, especially infants and young children; adults in most cases can be examined satisfactorily by either mirror or speculum. For carrying out treatment in children and adults the writer much prefers the speculum.

Method of Examination.—The method of examining the larynx with the laryngeal mirror is too well known to require description. Direct inspection is a newer procedure and requires a few words. Suppose the patient to be examined is a child, and the speculum to be employed either that of Jackson or the writer's, since these are the two forms which are the easiest to use. The child is wrapped and pinned in a blanket as for intubation, and held upright in the arms of a nurse, with the child's head on her shoulder. The typical method of introducing the speculum is to have the head of the child extended slightly backward and to pass the self-lighted speculum over the center of the dorsum of the tongue until the tip of the epiglottis comes in sight. The forefinger and thumb of the left hand of the physician hold the upper lip of the patient out of the way. The end of the speculum is made to pass over and a little beyond this so that it is engaged by the instrument. Then forward traction on the handle brings the point of the speculum forward and with it the epiglottis and the base of the tongue. With the beginner a hitch in the examination often occurs at this point. This is due to missing the tip of the epiglottis and going so far backward that the end of the instrument strikes the posterior wall of the pharynx. This causes bleeding and uncontrollable gagging. If this misadventure happens the speculum should be withdrawn and reintroduced.

In examining an adult by the direct method the pharynx and larynx are anesthetized, the first with ten per cent., and the larynx with twenty per cent. cocaine and the examination made with the patient sitting on a low stool with an attendant standing behind and holding his head, or the patient may lie on a table if the operator prefers. In order to operate upon the larynx the lumen is first exposed as has just been described, and whatever operative procedure the case calls for is carried out through the speculum. In operative work the open adjustable speculum is more serviceable than the tubular one.

Within the last few years the direct method of examination and treatment has been made easier by the introduction of suspension laryngoscopy (*q. v.*). This has as its essential principle the hanging of the patient's head from a suitable crane by elongating the handle of the speculum, and swinging this from the arm of the crane. The procedure frees the left hand of the physician from the weight of the patient's head and leaves it free to help in the operative manipulations. Naturally it has been found that when one has both hands to work with better and more extensive work can be carried on within the cavity of the larynx.

Stenosis due to Congenital Webs.—When the examination shows a congenital web uniting the vocal cords and so causing stenosis, the obvious treatment is to cut the web. Such webs are easily divided by the direct method. If the tissue which forms them is considerable it may call for excision. This is best accomplished by suspension laryngoscopy. Congenital webs of the larynx are generally placed between the anterior halves of the vocal cords.

Stenosis due to Infection.—Chief among the infectious diseases which cause stenosis of the larynx is diphtheria. When this is an extension of faucial or nasal diphtheria the diagnosis and treatment are comparatively simple. At times, however, laryngeal diphtheria exists by itself. There is no membrane in the nose or throat and cultures even from the deep pharynx are negative. Laryngeal obstruction which occurs only at night is croup, laryngeal obstruction which occurs in the daytime is diphtheria. Direct examination is of the utmost value in determining the presence or absence of this condition. Any case of persistent laryngeal obstruction calls for direct examination. The writer has uncovered two unsuspected cases of diphtheria in this way. A look at the larynx shows at once whether or not there is membrane present, and the amount, and if there is sufficient obstruction intubation can be at once performed. In the Contagious Department of the Boston City Hospital it has become the routine to examine in this way every case of laryngeal obstruction. In the writer's opinion direct diagnosis of membrane in the larynx and direct intubation and extu-

bation should soon prove, at least in institutions, a strong rival of the indirect method. Direct intubation is certainly the more logical. Of the acute infections, diphtheria is the commonest cause of laryngeal obstruction in a child, in adults other infections play a more prominent part. Certain systemic diseases like nephritis occasionally lead to edema of the larynx and its partial occlusion. The more frequent cause of acute laryngeal obstruction in the adult, however, is an extension downward of an infection from the fauces or from the pharynx. Any of the common bacteria may be at the bottom of this. Not rarely the inflammatory process originates in the larynx and is confined there. The modern method of dealing with a case of this kind is as follows: The pharynx and larynx are anesthetized with cocaine. This is best done with the laryngeal mirror. The mirror is used also to examine the larynx and to show its condition. In many instances the larynx is intensely injected and its various parts swollen, the epiglottis being large and pillow like, the arytenoids the same as well as the false cords. Below the true cords the subglottic tissue is engorged and swollen. The aryteno-epiglottic folds share in the general thickening and the vocal cords are buried from sight in the swelling of the tissues above and below them. In still other cases there is the same general swelling of the whole larynx with partial obliteration of the air channel, but the swelling is more of an edema so that the larynx on examination is white instead of red. In the cases where the inflammatory signs predominate it is not rare to have pus form at some point, the region of the arytenoid being a favorite place. Having made out the condition of the larynx by the mirror the physician does best in the writer's opinion if he carries out the treatment by the direct method.

Treatment.—Stenosis due to diphtheria calls for antitoxin and intubation. If these two measures do not relieve, tracheotomy is necessary. Edema calls for multiple puncture of the swollen tissues or scarification and appropriate systemic treatment. In the stenosis of adults due to infection, if an abscess can be located it should be opened. Failing in this, scarification may be of some service combined with the inhalation of medicated steam and the use of an icebag placed on the outside of the neck. If these measures fail, intubation or tracheotomy may be necessary. In the adult direct intubation is easier than the indirect.

Stenosis due to Papilloma.—Papilloma of the larynx is an insidious cause of stenosis. The signs of this condition are: diminution of the voice to a whisper with increasing difficulty in breathing and superimposed on these symptoms occasional alarming attacks of dyspnea. The mirror, or better direct examination, shows the presence of the mulberry-like growths. They may occur singly or may be multiple and almost fill the lumen of the larynx. Histologically a papilloma is a wart and like the familiar wart of the skin after a time tends to disappear.

Treatment.—The aim of the treatment of papilloma of the larynx is to keep the patient from choking to death until such a time as the warts have lived their cycle and disappear of themselves. The time of disappearance varies with the individual case. It may be three or four years before this welcome tendency manifests itself. Papillomata can be made to disappear temporarily by many methods. Chief among these is excision by the direct method. For accomplishing this grasping and punch forceps and the wire curette of the writer are the most useful instruments. The list of remedies tried for the eradication of these growths is a very long one. Single removal is seldom permanently successful. The methods of treatment which have been tried most are the instillation of alcohol, in order to desiccate the growths, repeated removal by punch forceps, and fulguration. Recurrences are the rule until the growth of its own volition ceases to return. Radium of course has been tried of late, and it is credited with removal of the growths. Whether or not its use will be followed by their permanent disappearance has not yet been determined. Syphilographers have noticed that during the administration of salvarsan warts of the skin disappear. A hint might be taken from this and an experimental injection of salvarsan given in certain cases. (Coolidge.)

Another method and a new one which promises well is the procedure of Lynch. By means of suspension laryngoscopy and appropriate instruments he dissects out the masses of papilloma the same as the surgeon cuts out a skin wart and then sutures the mucous membrane. He reports some very striking results. For the performance of this procedure naturally the growths have to be somewhat grouped and pedunculated. Until this method has been tried out a little longer and more operators have acquired the skill to do it, the management of the ordinary case of papilloma of the larynx should be along the following lines:

If the patient is a child and the examination shows that the larynx is moderately full of papilloma, a tracheotomy should be done. Often the giving of ether in such cases is a dangerous procedure but it can be made safe and the tracheotomy rendered deliberate instead of hurried, by first intubing with a small bronchoscope or with the writer's emergency intubation tube which is practically the same thing. Such an instrument should always be at hand during any work upon papilloma. The child intubed, then, and the tracheotomy carried out deliberately, the physician clears the larynx of the growths by the direct method. He uses his discretion as to when he shall repeat the cleaning out. If the growths recur speedily, as shown by the quick loss of the voice, it is not worth while to attack the papilloma again for some months. The tracheotomy tube gives the larynx rest, and is worn until the activity of the growths has exhausted itself. Favorable cases show a disappearance inside of two years. This is the treatment long advocated by Clark and recently concurred in by Smith who for some years has made a special study of this disease. It is usually possible to manage papillomata in the adult without tracheotomy. The preference of the writer is to operate by the direct method. Many cases, however, have been successfully operated upon by the indirect method.

Stenosis due to Scar Tissue.—After long wearing of an intubation tube the vocal cords are prone to adhere for a certain part of their length. Together with this there is often subglottic thickening. In typhoid fever occasionally there is involvement of the larynx which leaves its lumen narrowed. Any ulcerative process involving the larynx may do this. Chief among these conditions is syphilis. This even more than typhoid fever causes a chondritis which when it has healed leaves the lumen of the larynx narrowed and distorted. The physician in these cases is dealing with scar tissue and must be prepared for a siege as he has its unenviable qualities of contraction and recurrence to combat. This means that the treatment is tedious and often very discouraging for patient, parent, and physician. Recovery after the removal of papillomata leaves the patient with a good speaking voice. After a successful removal of scar tissue there is no laryngeal voice, only a whisper which is made in the pharynx.

Treatment.—There are two ways of attacking stenosis of the larynx due to scar tissue, the internal, or the method of prolonged intubation and dilatation; and the external.

The aim of the internal method is to dilate the lumen of the larynx by an appropriate instrument,

such as a male urethral sound, or a Kollman dilator, and to maintain the increase in size by prolonged intubation until the tendency of the scar tissue to retract is overcome. If there is much narrowing it is safer to do a tracheotomy at the start in order that a retaining apparatus may be applied to the intubation tube, otherwise there is great danger that it may be coughed out and the patient strangle to death. Instances of this happening are not rare. The writer prefers to accomplish the dilatation and the introduction and removal of the intubation tube by the direct method.

If a child with postdiphtheritic adhesions is before the physician on the examining table, the following is the technique of the treatment: As soon as the etherization is well started the larynx is intubed with the intubation bronchoscope. Should respiration be difficult this procedure is carried out as soon as the ether is started or even before. When the anesthesia is complete and the tracheotomy performed the larynx is examined by suspension laryngoscopy. If the adhesions are such that they can be cut they are divided, if on the contrary there is a general narrowing of the larynx the Kollman dilator is inserted and expanded until an intubation tube a little larger than that which the age of the child calls for, can be inserted. This is clamped in place by a retaining apparatus inserted through the tracheotomy wound. It may not be possible to get a full sized tube into the larynx at the first examination. If such is the case the operator has to content himself with one which fits snugly. This is left in place some weeks, four or six, according to the time when it becomes foul. Then it is taken out, cleaned, and reintroduced. After a few months the tube may be left out altogether, the child of course being under hospital observation, in order to see what the larynx will do. When this is done often it will be found on examining the larynx that the muscles have not regained their function, and that the arytenoids fall aimlessly about. The crowing respiration soon returns and the tube has to go back, usually quickly. Once in place again the tube is worn a few months more. In favorable cases a time finally comes, and experiment alone will determine when this has arrived when the larynx can stand alone again. Histologically such a larynx is a poor affair; it is mostly scar tissue reinforced by the distorted and partially ossified thyroid and the cricoid cartilages. Success can be gained by this method as Rogers and others have shown, but it is by no means certain.

So discouraging and uncertain is the method of prolonged intubation for the cure of advanced cases of stenosis of the larynx that many operators early turn to the external method. The external method is fully as tedious as the internal. The principle of the external operation is simple. The larynx is laid open from the front, the scar tissue removed, and its cavity allowed to epidermatize from the edges of the skin incision. When this process is complete a plastic skin operation is performed to close the larynx from the front. Contraction of the larynx is prevented by having the patient wear a tracheotomy tube which bears an upward spur supporting a piece of rubber tubing. This is worn while the process of epidermatization is going on. The pressure of the tubing absorbs the remaining scar tissue and maintains the lumen of the larynx. The healing by this method is a matter of six to nine months.

HARRIS P. MOSHER.

Larynx, Syphilis of the.—The period from the primary infection to the development of general infection, as evidenced in the larynx, varies from eight weeks to three months, but the latter may occur as late as twenty or even thirty years after the primary inoculation. Primary syphilis of the larynx is an extremely rare condition, only two cases so far as the writer has been able to discover, having been reported one by Krishaber in 1877, and the second one by Moure in 1890. The lesions met with in acquired laryngeal syphilis are, therefore, of the secondary and tertiary type, and concomitantly with these there are frequently cutaneous lesions corresponding to each period. The larynx, from its liability to various forms of catarrhal trouble, is especially apt, on account of its thus lowered resisting power, to show lesions of syphilis. From the frequency with which they are exposed, through the variety of occupations of life, to catarrhal conditions of the respiratory passages, men as it appears from a review of the statistics of numerous authors on this subject are more liable than women to have syphilis of the larynx. The question of the relative frequency of secondary and tertiary laryngeal manifestations is variously stated by different authors. In the writer's experience the tertiary manifestations have been the more frequent. There is no relation between the character of either the primary or the secondary manifestations and the subsequent tertiary symptoms. In a few cases neither the physician nor the patient himself has been able to detect any evidence of primary infection, and even secondary manifestations may not be noticed; and the only evidence one has that a former infection has occurred is the presence of extensive tertiary ulceration.

ETIOLOGY.—As a result of the untiring efforts of Schaudinn it is now definitely recognized that syphilis is due to *Spirochæta pallida* which was first described by him in 1905.

OBJECTIVE SYMPTOMS.—The lesions which manifest themselves are of the secondary and tertiary stages: The most common lesions of the secondary stage are. (1) erythema; (2) superficial ulceration; (3) a mucous patch, and (4) condylomata.

Upon laryngoscopic examination the mucous membrane will be found to be uniformly hyperemic, thus presenting essentially the same appearance as that of an ordinary acute laryngitis, or it may show an irregularity in the distribution of the inflammatory areas, this irregularity being due to interposed areas which are non-vascular, and the whole picture presenting a so-called mottled appearance which, as some authors maintain, is definitely characteristic of secondary syphilis.

The areas involved in the inflammatory process are generally the epiglottis, the false and the true cords. In cases in which the inflammation is uniformly distributed and persistent, its specific nature may be inferred from the fact that it does not yield to anything but definite antisyphilitic treatment. This inflammatory process may lead to a destruction of the superficial layer of the mucous membrane, in which case there will then be seen a small, shallow, and irregularly shaped ulcer whose surface is covered with a yellowish-colored secretion. The superficial ulcers may extend and unite with others, and when healed leave a very thin, stellate-looking cicatrix.

The occurrence of the mucous patch within the larynx is doubted by many, and on the other hand, there are some who believe that it occurs frequently in this locality. As a feature of secondary laryngeal syphilis it evidently occurs with comparative rarity. In appearance the laryngeal mucous patch is similar to that which occurs in the mouth; there is a thickening of the mucous membrane, rounded, oval, or oblong in outline, of a whitish-gray or yellowish color, and surrounded by an area which is markedly hyperemic. The surface of the patch may be either elevated or depressed. The localities where such a patch may be seen are the laryngeal surface of the epiglottis and its edges, the aryepiglottidean fold, and the false and true cords. This lesion is generally associated with the earliest syphilides.

Condylomata in the larynx appear as rounded or

oval elevations with a yellowish-colored surface; they seem like aggregated mucous patches. Whistler has called attention to a relapsing ulcerative laryngitis, which marks an intermediary stage between the secondary and the tertiary forms, and is characterized by a loss of substance of the mucous membrane neither so extensive nor so deep as that which occurs in the tertiary form. This ulceration attacks, in order of frequency, the vocal cords, the interarytenoidean space, and the false cords.

Tertiary Syphilis manifests itself in the three forms of a gumma, an ulceration, and cicatricial tissue. These conditions exhibit themselves in succession within a period varying from three to twenty or more years after primary infection.

The gumma presents itself as an infiltration, varying from the size of a very small pea to a size sufficient to produce obstructive symptoms. In appearance the mucous membrane covering it may be normal or of a darker hue, elevated above the surrounding mucous membrane, and its base presenting an area of inflammation of a deep rose color. It may be found on the laryngeal surface and edges of the epiglottis, the aryepiglottidean folds, the interarytenoidean space, the false cords, and the subglottic region. The gumma is usually single but may be multiple. With the progress of time the gumma undergoes a retrograde metamorphosis, as a result of which it becomes yellowish in color and at last breaking down, presents the stage of *ulceration*.

The ulcer thus formed has generally a circular outline, edges which are ragged and thickened, a surface excavated and covered with a dirty yellowish-colored secretion, and a base displaying a zone of hyperemia. The ulcer is usually single, but sometimes there are several of them, corresponding to the areas previously occupied by gummata. If neglected the inflammatory process may extend to the deeper-lying structures, and a perichondritis with subsequent abscess formation, necrosis of the cartilage and its exfoliation, may ensue. Perichondritis may, however, occur without ulceration. It is in this stage of ulceration that dangerous symptoms are apt to supervene. An edema, either acute or chronic, may arise and produce symptoms of marked dyspnea; or the exfoliated cartilage

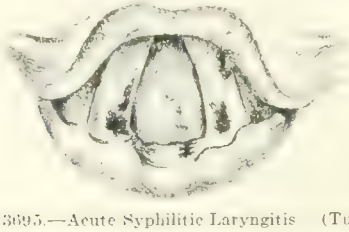


Fig. 3695.—Acute Syphilitic Laryngitis (Türck.)

may obstruct the respiratory tract, or the loss of the cartilage—especially if it be a portion of the thyroid, cricoid, or arytenoid—may lead to such collapse of the larynx proper as very materially to interfere with respiration. The epiglottis may be involved to such an extent as to interfere with the process of deglutition and allow portions of food to enter the larynx. Fixation of one or both vocal cords, as a result of a perichondritis or chondritis, may lead in some cases to a narrowing of the rima glottidis and consequent dyspnea. Myopathic paralysis of the abductors is not of common occurrence, but of very serious moment when present. Finally, hemorrhage may occur and may even result fatally, but, fortunately, this happens rarely.

The final step of the tertiary stage is that of cicatrization. The result of a healed syphilitic ulcer may present itself in many forms. The less extensive cicatrization is evidenced by a white stellate scar of varying extent. The results of ulceration and cicatrization of adjacent structures often lead to the epiglottis being bound down to the base of the tongue, or to the posterior or the lateral walls of the pharynx. Bands may be stretched across the lumen of the larynx and by their contraction lead to great distortion of its structures. Again, adhesions between the vocal cords may result in web-like bands which may involve the glottis to a greater or lesser degree. The cicatricial process may be so severe as simply to convert the larynx into a mass of cicatricial tissue with a small perforation in the center acting as the glottis.

Subjective Symptoms.—In the secondary stage the subjective symptoms are usually those of a severe acute laryngitis: the voice is husky and even aphonic, there is moderate cough with expectoration of a small amount of tenacious secretion, and, if the epiglottis be involved, deglutition may be painful. In the tertiary stage the symptoms are more pronounced. The alteration in the character of the voice varies from a slight huskiness to complete aphonia. Dysphagia is

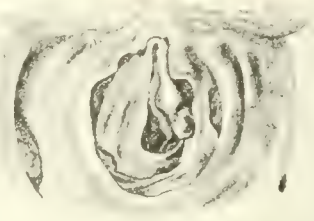


Fig. 3696.—Extensive Destruction and Cicatrization of the Epiglottis; Involvement of the False and True Vocal Cords; Stenosis of the Pharynx from Adhesion of the Epiglottis to the Root of the Tongue and Posterior and Lateral Walls of the Pharynx. (Türck.)

apt to be a more frequent symptom in this than in the secondary stage, owing to the involvement of the epiglottis in the inflammatory and destructive processes. Occasionally food finds its way into the larynx when the epiglottis is involved in the destructive process, but it is astonishing how readily patients in whom the epiglottis is totally destroyed learn to swallow without food entering or obstructing the larynx.

It is in the tertiary stage that sudden edema is apt to supervene, and it may produce such grave symptoms of stenosis as to necessitate immediate tracheotomy. When a suppurative process is going on in the larynx there is apt to be marked general disturbance, the temperature rising to 102° or 103° F. Externally, the perichondritis or suppurative process may be marked by swelling and tenderness over the affected part, and with destruction of the cartilage and its exfoliation there is always danger of the exfoliated portion obstructing respiration. The breath, when the disease has reached such a stage, is usually very offensive; the expectoration is mucopurulent in character, sometimes tinged with blood, and it may contain fragments of necrotic tissue.

Diagnosis.—The recognition of the primary lesion in cases of very recent infection can readily be determined by submitting the scrapings from it to microscopical investigation and determining the presence or absence of the *Spirochæta pallida*. When the symptoms of syphilis are showing themselves by mucous placques the etiological factor may also be demonstrated in them. These manifestations as well as those of a later period may now be recognized through the work of Wassermann, Neisser and Bruck, who introduced the indirect method of diagnosis by serum reaction, which reveals the presence of the disease when all outward symptoms have disappeared.

Where the facilities of carrying out the foregoing tests do not exist, one may be assisted to some de-

gree as regards a differential diagnosis by noting the following remarks: It is the diffuse laryngitis of the secondary stage that alone requires differentiating from the non-specific acute catarrhal laryngitis. Objectively, there may be at times, and especially when the inflammation is uniformly disposed, considerable difficulty in deciding which of the two conditions one has to deal with. Under such circumstances it will be found that the non-specific form of laryngitis will yield to the usual methods of treatment, while one should always be suspicious of a laryngitis which resists such treatment. A laryngitis which occurs in a tuberculous subject may also resist local treatment, but in this case there are marked pallor of the soft palate and an irritable condition of the posterior wall of the pharynx, and a careful examination of the patient's general condition and of the sputum will very

Fig. 3697.—Membranous Adhesion between the True Vocal Cords. (Türck.)

materially aid in clearing up the diagnosis. It is, however, more in the ulcerative form of the disease that difficulties of diagnosis present themselves; the diseases from which syphilis of the larynx in this stage requires to be differentiated being tuberculosis and carcinoma.

In tuberculosis the ulcers are apt to be numerous, the outline not so sharp or distinct, the edges less indurated, the surface not so deeply excavated, and the granulations pale and indolent-looking; the mucous membrane of the soft palate, pharynx, and larynx is distinctly pale; there is some general febrile disturbance (99.4° to 101° F.) with increased rate of pulse; and the general appearance of the patient is commonly that of a person suffering from anemia. Smears from the ulcerated areas will often reveal the presence of tubercle bacilli, and an examination of the expectoration will generally give a like result. It must be borne in mind that the two diseases may coexist; the ulceration, being originally syphilitic, may take on tuberculous action.

In carcinoma the difficulty of a differential diagnosis is much greater. Here a new growth precedes the stage of ulceration, and it is in this latter condition that the difficulty of a diagnosis so often arises. In carcinoma the disease presents itself more frequently as an ulcerating outgrowth, rather than as a true, deep, excavating ulcer such as is observed in syphilis. The ulcerating outgrowth has a more vascularized appearance and bleeds very easily on manipulation. The surrounding inflammatory area is of a much deeper color than that which is seen in syphilis. The progress of a carcinomatous ulcer is much slower than that of a syphilitic one. Other subsidiary points which are frequently considered in the question of a differential diagnosis, are: the age of the patient, the presence or absence of enlarged glands, and the existence of pain. But, in the writer's experience, these afford very little support for either view of the case.

Microscopical examination of a portion removed is often doubtful in its results, but recourse should always be had to it, for occasionally it has given satisfactory aid. But the writer has, on the other hand, repeatedly subjected portions thus removed to examination with a very unsatisfactory result. This, however, may be explained by the fact that the portion removed has not been from the more deeply situated tissue. In doubtful cases, recourse to proper antisyphilitic remedies may clear up the difficulty, and yet one must not be too sanguine as to ultimate results, for the iodide of potassium has often the effect of producing absorption of the inflammatory products in cases of carcinoma and thus materially altering the picture presented. One is sometimes confronted with the further difficulty of finding the two diseases (syphilis and carcinoma) coexisting.

Prognosis.—The prognosis to be expressed in any given case of syphilis of the larynx depends upon: (1) the absence of any other coexisting disease (tuberculosis and carcinoma); (2) the extent of the existing lesions; and (3) the faithfulness with which the patient will adhere to treatment and advice. In the secondary lesions recovery usually takes place without leaving any noticeable after-result. In the tertiary stage, when ulceration is present, the progress is usually readily arrested and the function of the larynx interfered with only so far as the destructive process has extended. When cicatrization has occurred very little improvement is to be expected from treatment.

Treatment.—Salvarsan first introduced by Ehrlich in 1910 as a therapeutic agent in the cure of syphilis has long passed the experimental stage. Its use is indicated in any form of lesion manifesting itself in the larynx. The use of salvarsan or neosalvarsan is, however, not always possible. Then, one must fall back on the method of treatment by mercury.

The treatment of syphilis of the larynx is similar to that of syphilis affecting other parts of the body. In the secondary manifestations the method of administration of mercury by inunction furnishes by far the most satisfactory results. It must be admitted that at times it is very difficult to carry out this mode of treatment with any degree of thoroughness; and yet, unless this be done, one can scarcely hope to secure very satisfactory results.

Locally, alkaline sprays, such as Dobell's and Seiler's, and sedative inhalations (compound tincture of benzoin) are indicated, and, after the subsidence of the acute stage, applications of weak solutions (gr. xx.–xxx. to the ounce) of nitrate of silver may be made to the larynx. In the tertiary manifestations (gummatous and ulcerous infiltration) iodide of potassium in increasing doses is indicated. The writer's method of giving it is in a saturated solution (one ounce of the iodide to one ounce of water), each drop of which approximately represents one grain of the iodide. It is well to begin with small doses, ten drops, to be taken in half a tumblerful of water three times a day *before* meals. It is to be noted that most physicians prescribe the iodide after meals, and this is the reason, the writer thinks, why one frequently hears the complaint that the iodide disagrees with the patient, producing symptoms of indigestion. And so it does, for the iodide of potassium given after meals neutralizes to a very great extent the action of the gastric juice. The writer has repeatedly met with patients who have made such complaints; but, upon their taking the iodide before meals, not only did they find that it agreed with them but they were able to take it in much larger doses. The quantity of the iodide should be slowly increased, and, if we watch its effect upon the ulceration or the gummatous condition, we may find it necessary to increase the dose to gr. l. or lx. three times a day. The chief points in the administration of this drug for syphilitic affections are, that it should be taken before meals and that it should be largely diluted. The acne accompanying the use of the iodide may be moderated by the administration of small doses (♏i.–iij.) of Fowler's solution after meals.

Locally, cleansing the ulcerated area with alkaline and antiseptic sprays and the subsequent application

of a solution of nitrate of silver (gr. xx. or xxx. to the ounce), or the insufflation of iodoform or iodol, will very materially assist in the healing process and moderate the offensiveness of the breath. Vegetations may require the use of the curette, forceps, galvanocautery, or chromic acid, to hasten their disappearance. Neither general nor local treatment avails when fibroid changes with extensive hypertrophy have already taken place. The local treatment of adhesions and of fibrous bands or membranes, and of stenosis of the larynx, is dealt with in the article on *Stenosis*, to which the reader is referred.

When syphilis and tuberculosis coexist it is generally agreed that the syphilitic element should first receive treatment. In all forms of syphilis of the larynx smoking and the use of alcohol in any form should be prohibited.

Syphilis of the Trachea and Bronchi. The trachea and bronchi are less frequently involved in the syphilitic process than are the upper portions of the respiratory tract. It is rare to find these regions involved, however, without existing lesions in the remaining portion of the respiratory tract, for usually the conditions here found are extensions of the process existing above. Mucous patches have occasionally been met with and may be found situated in any portion of the trachea. Gummata, in the writer's experience, are more frequently met with; they are usually single, although occasionally several are present at the same time. As regards the situation occupied by these lesions, I may say that those which I saw (three cases) were located on the posterior wall of the trachea. They vary in size and to such a degree that in some cases they may produce no symptoms at all, while in others they may give rise to the symptoms of increasing stenosis. In the ulcerative stage the lesions may, as in the case of the gummata, be multiple, but usually they are single and very extensive. Cicatrization is also apt to be extensive, the affected areas assuming a great variety of shapes. (Fig. 3698.)

Fig. 3698.—Syphilitic Cicatrices of the Larynx and Trachea. (Orth's "Pathologische Anatomie.")

The *symptoms* depend upon the nature and extent of the lesions present. In some cases they may be insignificant, but in others they are alarming, especially when stenosis exists.

The *prognosis* of syphilis in these regions is more unfavorable than when the disease affects the larynx, there being greater danger of hemorrhage from perforation of the ulcer into the aorta or the pulmonary artery. Perforation has also taken place into the mediastinum or into the esophagus. When stenosis exists as the result of cicatrization the outlook is very grave.

The *treatment* resolves itself into that of syphilis in general. Local treatment cannot be carried out with any degree of certainty.

Congenital Syphilis of the Larynx, Trachea, and Bronchi.—Congenital syphilis of these regions has long been recognized but in an indifferent way, and it remained for John N. Mackenzie to draw the attention of the profession to its more frequent occurrence than was generally admitted, by a most scholarly article which appeared in the *American Journal of the Medical Sciences* in 1880. And, as the writer has seen only seven cases within his own experience, he has largely drawn upon Mackenzie's paper for the full and elaborate information there given of this interesting subject.

"Laryngeal affections in congenital syphilis are the most common and characteristic of its pathological phenomena, and invasion of the larynx may be looked for with the same confidence in the congenital as in the acquired form of the disease."

The larynx may be involved at any age, but the disease more commonly shows itself within the first six months after birth. In the writer's cases the ages were as follows: Two within the first year, three between the ages of four and five years, and two between the ages of six and ten years. As to sex, it is more frequently met with in the female—in the proportion of three to two (Mackenzie). In the writer's cases, four were females and three males. In congenital syphilis of the larynx three distinct forms are to be met with: In the first, the lesions involve the mucous membrane and the submucosa; in the second, the lesions involve the deeper structures, and are characterized by extensive ulceration rapidly involving the cartilaginous framework of the larynx; in the third form, there is a deposit of dense, fibrous tissue leading subsequently to contraction and stenosis.

Symptoms.—In the early manifestations of the disease the subjective symptoms are those of an intense laryngitis, the voice being quite hoarse, and in two of the writer's cases, seen in infancy, nothing more than a very marked hyperemia of all the laryngeal structures was observed, the examination being carried out under a general anesthetic. The coexistence of cutaneous syphilis is of frequent occurrence. In the secondary stage the presence of extensive ulceration involving the epiglottis and laryngeal structures leads to the cry of the child being extremely hoarse and more deeply pitched than in the early stages. The cough is harsh and paroxysmal, leading frequently to an attack of vomiting, and deglutition is often difficult.

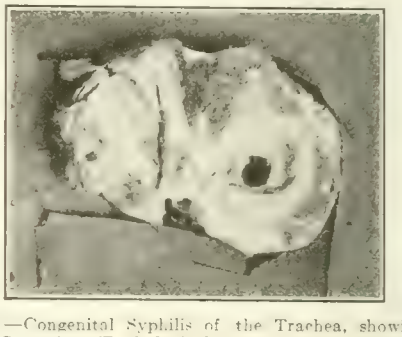


Fig. 3699.—Congenital Syphilis of the Trachea, showing very marked Stenosis. (Pathological Museum, McGill University.)

In the third variety the voice is almost aphonic, and, in consequence of the lumen of the larynx and trachea being considerably reduced, there is marked respiratory difficulty, amounting in some cases to orthopnea, cyanosis, and convulsions. The degree to which stenosis of the trachea may reach in this form is well shown in the accompanying figure taken from a specimen in the Museum of the Medical Faculty of McGill University (Fig. 3699).

Diagnosis.—In the Wassermann serum reaction, we have a very satisfactory method of clearing up any doubtful cases of hereditary syphilis. In the early forms of the disease it may be mistaken for simple laryngitis, but often there are other symptoms of the inherited form to be seen in the skin and mucous membranes of the mouth and throat. In the more

advanced form the evidence of the disease may be found in the state of the teeth, the condition of the eyes, and the presence of cicatrices about the angles of the mouth.

Prognosis.—The prognosis of congenital syphilis of these regions is always grave, but less so in the earlier stages, when, if the affection be recognized and treated, favorable results may be looked for. In the later forms of the disease, however, even when its true nature is recognized, the treatment seems to produce less effect than it does in the acquired form.

Treatment.—The use of salvarsan has in my hands in cases of hereditary syphilis proved to be very gratifying. I have only resorted to its use in children over ten years of age, but in those of younger years I have found that the best method of treating these forms of infantile syphilis is by the use of the mercurial ointment. A small quantity of this may be applied on the walls of the abdomen, and a flannel binder also containing a small quantity of the ointment may be applied about the body. One must be careful in using mercurial ointments on the skin of very young infants, as, owing to its being particularly sensitive, the application may do harm. Calomel, gr. $\frac{1}{4}$, three times a day for several weeks, or pulvis hydrargyri cum creta, gr. $\frac{1}{4}$–$\frac{1}{2}$, may also be given. General tonic treatment should follow a course of mercury.

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Larynx, Tuberculosis of the. —*Definition.*—Tuberculosis of the larynx is an inflammatory condition of the mucous membrane in which newly formed cells containing tubercle bacilli are found which frequently break down and form ulcers. The disease may involve the perichondrium and cartilage with a resulting necrosis and caries.

ETIOLOGY.—The infection may occur by means of the bacilli-laden sputum, possibly in conjunction with chemical irritation of the mucous membrane of the larynx by the irritated sputum, or there may be secondary infection by way of the blood-vessels or lymphatics. Primary tuberculosis of the larynx is rare and is more frequently found clinically than anatomically. Macroscopically a variety of forms of tuberculosis of the larynx can be differentiated.

As a general rule, laryngeal tuberculosis is secondary to pulmonary tuberculosis. It is much more common in males than in females and authorities vary as to the relative frequency. Thus Nowicki[1] found tuberculous alterations in one-half of 5,095 autopsies, and twenty-one per cent. of these were of the larynx and trachea; Lewies[2] found it to occur most frequently at the age of fifty; seventy-one per cent. of these were in males; while Harada and Yamoguchi[3] found but 1.5 per cent. of tuberculosis of the upper air passages in 42,441 nose and throat patients, and in sixteen per cent. of the necropsies the upper air passage was affected in 2,162 individuals.

L. D. Brose[4] believes that one-third of the pulmonary tuberculosis patients have laryngeal involvement. Judging from my own experience I would say that twenty-five per cent. of the patients afflicted with pulmonary tuberculosis have a laryngeal involvement ultimately.

Laryngeal tuberculosis occurs rarely among children. Nobecourt and Tixier[5] report a case occurring in an infant aged three and one-half months. Collet reported a case in a child of thirteen, and the same author collected four cases of tuberculosis in a thousand children of all ages, while Lockard,[7] Solis Cohen, J. N. Mackenzie, Moritz Schmidt, and W. J. Horn have recorded instances of this affection in young children, as stated by Hunt[8] who also records the case of an infant of seventeen months in whom a tracheotomy had to be performed for stenosis. At the autopsy both lungs were found riddled with miliary tuberculosis, and there was a smooth walled cavity at the right apex the size of a walnut, and also large glands. There was an ulcer of the right aryepiglottic fold and ventricular band and the left arytenoid with granulations over the ulcerated surface.

It is believed that the disease would be found more frequently among children if it were not for the fact that they succumb to the pulmonary tuberculosis long before there is an opportunity for involvement of the larynx.

Laryngeal tuberculosis is an occupational disease as with stone cutters, bakers, and workers in dust-laden factories, and the use of tobacco seems to have a decided influence in the tendency toward the production of tuberculosis. Labatt[9] investigated a number of patients who were chewers of snuff and found sixty-four per cent. of the cases addicted to this habit; forty-one per cent. of the total number were smokers, while twenty-five per cent. were non-users of tobacco.

As a predisposing factor to pulmonary tuberculosis McCambridge[10] believes that nasal obstruction is responsible for producing laryngeal and pulmonary tuberculosis.

PATHOLOGY.—A. Rather sharply circumscribed lentil-shaped ulcerations beginning superficially, usually on the inner surface of the epiglottis, and at first very easily overlooked, with a pale yellowish-gray base, frequently confluent, forming grape-like circumscribed figures. This process may eventually cover the entire larynx. Small miliary nodules eventually form under the epithelium of the mucous membrane which break down, become cheesy and ulcerate, forming an erosion of the overlying tissue. Before these nodules can be observed macroscopically they have usually broken down and ulcerated. In the depths and in the edges of the ulcerations new tubercles form by means of which the defect is spread and deepened and the lenticular character of the lesions is lost more and more. The process becomes deeper, shows cheesy masses and nodules, and the edges become ragged and irregular. These ulcerative processes may progress and eventually involve the cartilage of the larynx producing a perichondritis.

B. Tuberculous infiltrations may occur in the depths of the mucous membrane which on breaking down form deep ulcerations; then a thickened lardaceous area is formed in which cheesy yellowish degenerative areas occur. In these tubercle bacilli are found. The follicles are the first area of involvement of the tuberculous infiltration, and by the breaking down of these lesions deep irregular masses with jagged walls, uneven, with cheesy bases are formed. These infiltrations are present in those portions of the larynx with a spongy submucosa rich in follicular tissue, *e.g.* the epiglottis, false cords, and over the arytenoid cartilage, and often lead to a perichondritis. Fistulous tracts may occasionally be seen. According to Frankel, in the subsequent development of these ulcerations secondary infections with staphylococci and streptococci play a rôle.

C. This is a chronic form with the formation of

masses having a tendency to perichondritis. These ulcerations usually occur upon the arytenoid cartilage and are very deep, having an irregular hard wall. At times the true vocal cords show chronic ulcerations which are elongated and slit-like, and occasionally are so long and deep that they split the vocal cords. The vocal cords may be entirely destroyed with the incidence of aphonia. Often the vicinity of these lesions shows a milk-white thickening of the superficial epithelium.

D. This form, which occurs only occasionally, shows masses of polypoid excrescences of the mucous membrane caused by marked subepithelial development of tuberculous granular tissue. Usually the course of this form is very chronic. This is the tuberculosis laryngis hypertrophica of Ziegler. The interarytenoid region of the larynx is most frequently involved, but these lesions may occasionally occur in other portions of the larynx. They may break down and ulcerate and occasionally true polypoid exuberances occur.

Early Manifestations and Diagnosis.—Hoarseness is perhaps the earliest indication of beginning laryngeal involvement. This may be due to weakness in the motility of the vocal bands as a result of the general anemia of all the mucous membranes. Constant clearing of the throat and cough in addition to that previously existing may be present. In these early cases there is frequently a unilateral lesion with a lack of motility on that side and this unilateral manifestation is one of the earliest symptoms of laryngeal tuberculosis. Quite early in the onset of the disease there is a thickening in the interarytenoid space. This I consider to be a diagnostic sign (Plate XLII, Fig. 1) so much so that it is my invariable rule to insist upon a most careful examination made when this thickening is present to determine the presence of tuberculosis elsewhere, and it has happened very frequently that this early sign has led to the prompt discovery of tuberculosis that was not even suspected. I found that others had noted this, as Solenberger,[11] Lamberson,[12] and Hughes.[13] The latter speaks of it as the earliest manifestation in nearly every case and is inclined to believe that many cases of pulmonary tuberculosis have their origin in the larynx and that careful examination will reveal the fact. Casselberry[14] in speaking of the recognition of early changes of the larynx in tuberculosis mentions the "vocal angle," which was originally noted by C. L. Minor. This vocal angle marks the line at which the superficial structures of the true cord, the false cord, and the arytenoid fold merge into one. This is a hinge folding in and out with every movement of the vocal cord; a tuberculous infiltrate forms a furrow or fissure. This infiltrate may appear at any part of the vocal angle. He considers that as the most distinctive of all local changes of tuberculosis of the larynx, and at a period before interarytenoid hyperplasia. He says further, "if an infiltration at a vocal angle be recognized in addition to the questionable hyperplasia the diagnosis is laryngopulmonary tuberculosis." We have then in these two positive and distinct signs indubitable assistance toward the early diagnosis of tuberculosis. Dennis[15] places no reliance on the sign of pallor of the mucous membrane, but says that "a sign which has seemed to me to be so constantly present that I attach great importance to it is a thin line of mucopus which lies in the posterior commissure and extends up and over the interarytenoid region." Levy[16] mentions excessive sensitiveness and irritability of the pharynx as an early symptom.

Differential Diagnosis.—In the differential diagnosis we must consider simple catarrhal laryngitis, pachyderma, syphilis, carcinoma, posticus paralysis, rheumatic arthritis of the arytenoid joint, lupus, scleroma, and aphthous ulcers. It is quite important to bear in mind that there is a decided difference between the tuberculous laryngitis and the simple laryngitis of tuberculosis.

One of the most persistent symptoms of the presence of tuberculosis is pain. This may be of a very severe and lancinating character and may be so distressing as to prevent the patient from swallowing, thus adding materially to his weakness. In syphilis there is practically no pain, while pain is constant in malignant disease, and entirely absent in all of the other affections excepting the rheumatic. The slow process of ulceration, the great edema of the arytenoids, pale condition of the mucous membrane, previous impairment of the general health with indication of pulmonary complication, all point to the diagnosis of tuberculosis. Added to this the presence of tubercle bacilli which is only found also in lupus, and here the microscope comes to our aid and is absolutely to be relied upon. In doubtful cases the Wassermann reaction together with the past history would help indicate the presence of syphilis, but it must be borne in mind that both diseases may occur at the same time. In this connection Strandberg[17] says, "The differential diagnosis is at times very difficult, and even histological examination cannot be relied upon. A positive Wassermann reaction means much, but a negative report does not absolutely exclude the presence of syphilis. Hence in doubtful cases the test of antispecific treatment only remains, iodide of sodium up to ten grams (150 grains) daily, using 200 to 300 grams (seven to ten ounces) altogether. Besides, ten to fifteen mercurial injections are to be given. No improvement following this test, we are assured of the absence of syphilis." The aphthous ulcers occurring in the larynx in pulmonary tuberculosis were presented in a careful study by J. N. Mackenzie[18] who believed these to be due to streptococci in the sputum affecting the inner surface of the mucosa and resulting in ulceration and eventually possibly becoming infected with tubercle bacilli. Ziba Schinizi[19] has made a study of these aphthous ulcers recently and agrees in the main with Mackenzie. He believes that they are occasioned as a result of superficial diphtheritic inflammation and that it is a cellular infiltration of the tissues resulting in necrosis, the irritation of the mucous membrane as a result of the acrid tuberculous sputum being a causal factor. He has found the same ulcers in gangrene of the tongue, in perforation of the trachea following destruction of the bronchial glands, and in the vagina in purulent conditions.

As a further means of diagnosis, tuberculin may be injected, but it must be used under great precautions. The old tuberculin of Koch is the safer in these cases. The patient's temperature is to be taken every four hours for three days previous to the administration of the tuberculin and again after the injection. There is a decided rise of two to three degrees of temperature if tuberculosis exists and there is an increase of the infiltration in the larynx. This increase of the infiltration of the larynx may amount to an edema and hence in these cases much care should be exercised that the dose should begin with the smallest possible amount, lest suffocation ensue.

Prognosis.—In this particular we are most able to note the advance that modern methods have made in the successful treatment of this affection. It is not so very long ago that the diagnosis of tuberculous laryngitis meant an absolutely unfavorable prognosis, but so much has been done in this connection, so much faithful work and conscientious attention to the smallest possible details, that the literature abounds in case after case being reported as cured that were formerly considered as inevitably doomed. Nor are cases marked cured after improvement of a temporary nature, but, as stated by Brüll,[20] only those must be considered as cured in whom there was no sign of recurrence for at least two years. There are still certain conditions under which the prognosis in laryn-

Fig. 1.

Fig. 2

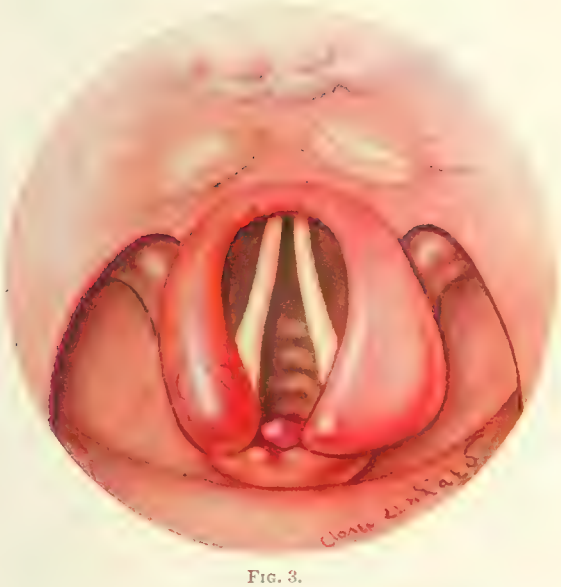

Fig. 3.

Fig. 4.

Tuberculosis and Lupus of Larynx.

(Original drawings from life made for this article under the direction of the author.

Fig. 1.—Interarytenoideal Thickening, one of the earliest pathological appearances of tuberculosis of the larynx.

Fig. 2.—Advanced Tuberculosis of the Larynx. Showing swollen epiglottis, edema of both arytenoids, interarytenoid thickening, and ulceration of false vocal cords.

Fig. 3.—Early Lupus of Larynx. Showing peculiar saddle-bag appearance of epiglottis, the remainder of larynx normal.

Fig. 4.—Advanced Lupus of Larynx. Showing destruction of epiglottis, with cicatrization, large indurations in the ventricles, while the remainder of larynx is entirely normal.

geal tuberculosis is absolutely bad, and especially is that the case when it occurs in connection with pregnancy. Where the tuberculosis is manifest early in pregnancy, Pankow and Kupferle[21] found that ninety per cent. are apt to become worse, and that fifty-six per cent. of these die within the year, while if the tuberculosis remains latent during pregnancy death ensues in but three per cent. While the tuberculous process may become active at any time during pregnancy the tendency is far greater immediately after confinement and the chances of the patient are greatly enhanced by artificial induction of labor within the first four months. More than one-half the children born of tuberculous mothers die within the first year and interruption of pregnancy in these circumstances is permitted by the criminal law of Germany. That pregnancy should be interrupted in all of the cases is the belief of Baumgarten,[22] Schroeder[23] and Bilancioni.[24] In cases of advanced tuberculosis pregnancy should not be interfered with in the interest of the child. To interrupt pregnancy in the interest of the mother it should be done only in the first months of pregnancy.

The prognosis of laryngeal tuberculosis must be considered from two points of view, that relating to its influence on the general condition and to a possible fatal termination, and that relating to its effect on the voice. Generally speaking, the advent of laryngeal complication adds to the gravity of the prognosis of pulmonary tuberculosis. This statement applies only to those cases in which the nature of the complication is of the rapidly active type with marked edematous swelling and abundant deposits of tubercles in the larynx. The seriousness of the prognosis of laryngeal tuberculosis increases with the lateness in the stage of the general disease in which the former develops. In that form of laryngeal tuberculosis in which there is little or no tendency to ulceration, the form characterized by more or less firm infiltration, the progress of the general disease is not materially augmented. Unquestionably the local and the pulmonary or general infection progress favorably or unfavorably one with the other, but on the whole the general infection is much more responsible for a failure to obtain laryngeal improvement than is the local affection for the general or pulmonary condition. On the other hand, the latter often improves in proportion to the favorable progress made in the larynx. This is especially true in those cases in which local treatment overcomes odynphagia, thus enabling the patient to keep up nutrition.

The prognosis as regards the restoration of the vocal function is of great importance. The mental distress occasioned by the loss of voice is often great, and although it must be looked upon as of less actual importance than the general systemic disturbances, its gravity should not be underestimated. Where complete loss of voice has occurred it cannot be restored to perfectly normal function; nevertheless a large proportion of voices can be restored to usefulness. Even in those cases in which extensive destruction of one vocal band has resulted or marked infiltration has been present, the patient may be rescued from a voiceless future. The cases offering the least hope in this particular are those in which the arytenoids and the interarytenoid space undergo extensive fibroid hypertrophy associated with perichondritis which invades the cricoarytenoid articulation (Plate XLII, Fig. 2).

Treatment.—When we speak of the curability of laryngeal tuberculosis we mean as a result of careful, conscientious and systematic treatment of the disease, for each case requires careful study and consideration and that form of treatment adapted to the particular case which will give the best results. Many suggestions have been made as to the manner of treating this affection and they are all here presented in their proper connection.

Vocal rest was suggested as far back as 1838. Complete cessation of speech has been followed by very satisfactory results; it requires determination little short of heroic, but wonderful results have followed faithful persistence in absolute silence.

Medicinal treatment may be divided into two forms—(1) those remedies which are supposed to act by directly destroying the tubercle bacilli; (2) symptom remedies for the relief of pain, cough, irritation, etc.

Hinman[25] has made applications twice daily of scarlet red, using a ten-per-cent. dye in equal parts of sesame oil and vaseline, with surprising beneficial results.

Pfannenstill[26] treats laryngeal tuberculosis with iodide of sodium and ozone. The iodide of sodium is given internally, 1.0 to 2.0 (fifteen to thirty grains) daily, followed by the inhalation of ozone. Where an inhalation apparatus is not at hand, free spraying of the parts with an acidulous peroxide of hydrogen solution takes the place of the ozone. Laryngeal cases with advanced pulmonary tuberculosis are not amenable to this treatment. He reports nine cures in fourteen cases with benefit to the remainder. A chemical action must occur, a freeing of iodine. The method acts only locally and hence the diseased condition must be within reach. Ohnmacht,[27] taking the suggestion of Pfannenstill, uses iodine locally and has a preparation made of a hydroiodine borate, a yellowish powder which is put up in sealed glass tubes and must be kept free from moisture. This preparation is called ulsanin. As soon as the powder becomes moist, it becomes dark brown and liberates a form of iodine and oxygen. Applications are made with a cotton swab direct to the part, much care being required that the powder should not become moist before it reaches the affected part. Fifteen out of seventeen ulcerations were decidedly benefited by means of this application.

Trichloracetic acid has been successfully used by Syltschow, being applied directly to the ulcerated part after thorough cocainization. Subcutaneous injections of oxygen are said to be beneficial by Lubiner.[28] Baumgarten[29] and Bosse[30] extol the use of cycloform or anesthesin with coryfin in four per cent. solution. Orthoform and propaesin are of great use in the treatment of painful laryngitis. Freudenthal[31] gives the following formula:

R.	Propaesin	5.0 (gr. 75)
	Formaldehyd	0.1 (gr. 15)
	Menthol	0.5 (gr. 7½)
	Ol. amygdal dulc.....	15.0 (gr. 225)
	Gum acacia.....	q.s
	Aq. dist. ad.....	50.0 (gr. 750)

Inhalations of the compound tincture of benzoin, eucalyptol, or creosote are of undoubted value in adding to the comfort of the patient. I prescribe the following:

℞.	Beechwood creosote.....	12.0 (dr. 3)
	Mag. carbonate.....	4.0 (dr. 1)
	Water.....	90.0 (oz. 3)

Mix, shake well, put one teaspoonful in a pint of boiling water, and inhale night and morning.

Formalin solutions two per cent. at first directly applied to the larynx are of value; it is important to cocainize the larynx first as the formalin is irritating to the respiratory tract.

The action of the rays of the sun and the Röntgen rays have been advised and extolled by Sari,[32] Janssen,[33] Alexandre,[34] Wilms,[35] and others, while Blumenthal[36] expresses his doubts, quoting Siebenmann who treated twenty cases externally with the Röntgen rays without any relief whatsoever; Brünings who applied the Röntgen rays through a tube placed in the patient's mouth, found no resulting benefit. Blumenthal's personal experience was with two cases,

and he states that the direct treatment of a tuberculous larynx with the rays of the sun or the Rontgen rays is of so negative a nature that its value is doubted. Edmund Meyer[37] has never seen a cure follow the use of the Rontgen rays in laryngeal tuberculosis. Freudenthal[38] advises fulguration. It lends a mild caustic effect destroying the ulcer so that it is not nearly so difficult to use as the galvanocautery. There is an antiseptic effect from the ozone produced by the current and there is no danger of an edema.

For the relief of pain, nothing has been suggested of late years that quite equals the use of alcohol injected in the superior laryngeal nerve. This was first suggested by Hoffman,[39] in 1908, and has been most enthusiastically commented upon by Combies,[40] Davis,[41] Mithoefer,[42] Renoux,[43] Karbowski,[44] Dundas Grant,[45] Roth,[46] Fetteroff,[47] and Horn[48] with remarkable unanimity; not a single dissent. This method, so much extolled, has proven entirely satisfactory in my own hands. The nerve lends itself particularly well to injection in that it is purely sensory. It supplies all of the lower and greater part of the upper larynx. It is comparatively near the surface and very accessible, and is fairly well removed from all vulnerable structures. Branching over from the superior laryngeal it passes obliquely downward and inward to pierce the outer portion of the thyrohyoid membrane. Having passed through the membrane it supplies all the interior of the larynx with sensory fibers with the exception of the epiglottis in whose supply the glossopharyngeal shares. Abolition of the function of this nerve therefore removes all sensation in the larynx except from some of those originating in the epiglottis.

The following is the technique: The patient is placed in the recumbent position with a pillow under the shoulders and the head extended and rotated away from the side of the neck to be injected. With an anilin pencil the lateral part of the thyrohyoid interval is explored until a tender spot is found and marked, this spot corresponding to the internal laryngeal nerve. With the thumb and fingers of the left hand the larynx is steadied and the needle is introduced at a right angle to the surface through the skin. After traversing the skin the needle seems to enter a cavity in which its point can move freely. It is then gradually pushed in in an attempt to elicit pain in the ear which would indicate that the point of the needle has come in contact with the nerve. The solution is a warmed eighty per cent. solution of alcohol. At first a drop or two is injected in order to be sure that the needle has not pierced the laryngeal mucosa and entered the larynx. If there is no cough a few more drops are forced out and the resulting burning sensation disappears. This takes but a minute or two and then the remainder of a syringeful is injected into the neck, a total of twenty to twenty-five minims being used for each injection. In this connection Horn[48] has treated cases with the alcohol injections where death was inevitable within a few weeks. The sufferings of these poor individuals were intense and the majority found the greatest relief from pain.

Opinions differ as to the value of the tuberculin treatment in this affection. Von Ruck[49] is an enthusiastic endorser. Matsuy[50] reports good results in two cases, while Edmund Meyer[51] who has given this matter a very careful study, declares it to be of value in carefully selected cases only. It is contraindicated in general debility, increased temperature, and advanced tuberculosis of the larynx.

Thost[52] calls attention to the need of this form of treatment in hospitals and sanatoria, as one patient treated in an ambulatory manner died of edema of the glottis following the injection. Blumenfeld,[53] who has also given this matter much attention, says that in chronic coughs with elevated temperature and those with a diazo reaction, tuberculin should not be used, its real domain being in the ulcerative cases; hence the best results are noted in ulcerations, and he has seen such torpid ulcers heal that have been unsuccessfully treated with lactic acid. Tuberculin is of no avail where a perichondritis or great infiltration of the arytenoids and the arytenoepiglottic folds exists. He begins usually with a very small dose of old tuberculin increasing gradually.

Robert Levy[16] endorses the use of tuberculin. Lockard[7] has seen no such benefit follow its use.

The Marmorek serum has not been of any benefit in the hands of Jeroslaw,[54] while Barenek's tuberculin failed entirely in the hands of Siebenmann.[55] Hutter[56] believes that tuberculin is of great value in operative cases, as healing is said to be much more apt to follow the treatment. This treatment is indicated if there is a status quo, slight local disturbance, fever and general condition poor, and when surgical treatment has been instituted. One should carefully weigh the indications before using tuberculin.

In one case Da Gradi[57] claims that improvement followed the treatment of pulmonary tuberculosis by artificial pneumothorax.

Surgical Treatment.—This may be a removal of the diseased part by means of the double curette or forceps, galvanocautery, tracheotomy, or external operations.

Lockard[7] removes the epiglottis entirely, and states that pain ceased in eighty per cent. of the cases that were operated upon.

Moeller[58] removed the epiglottis in twenty-five cases; as all these had advanced tuberculosis the results were not good; but one recovered, the remainder dying a few weeks or months after operation. Moeller, nevertheless, is an earnest advocate of this method, and gives the following indications for amputation:

1. Where the tuberculous disease is entirely in the epiglottis, and where the physical strength of the patient will at all permit.

2. Marked dysphagia without reference to the remainder of the larynx or the lungs.

3. In tuberculous affections of the epiglottis even if no dysphagia is present so long as the lungs are free from disease or are only slightly affected..

Ruedi[59] suggests the advisability of the cautery followed by the double curette. Kahler[60] employs cutting forceps and secures excellent results with the patient in the suspension laryngoscope. The galvanocautery was first suggested by Mermod. The danger of edema following was pointed out by some authors. Deep cauterizations are not followed by edema and are extolled by Bar,[61] Hajek,[62] Killian,[63] R. Levy,[16] and Pettit.[64]

Gluck and Sorenson,[65] as also Franceschi,[66] advocate total extirpation of the larynx. Sanpiquet[67] claims to have achieved wonderful results in one case by removing piece by piece the mucous membrane and perichondrium of the arytenoid first of one side and then the other.

Tracheotomy may be required for dyspnea and much benefit has followed this operation at times because of the enforced rest to the voice.

These then are the various methods now in vogue for the successful treatment of laryngeal tuberculosis.

To recapitulate: In the very early stages the best treatment consists of inhalations with local sprays of mild astringents like the tincture of chloride of iron and mild solution of iodine; rest of the voice as complete as possible, and finally close attention to the general health.

In this connection I would say that nothing that is advised for the successful treatment of laryngeal tuberculosis should interfere in any way with the care of the general health; on the contrary the treatments should go hand in hand with each other.

If pain exists local applications of an emulsion of orthoform or propaesin made daily, or this failing, a twenty-five per cent. solution of anesthesin in coryfin. These applications may be made by the patient and a simple and inexpensive method is the

small device of Yankauer. It consists of an elongated dropper and the distance that the glass tube may enter the mouth is marked off with a piece of adhesive plaster which just touches the line of the incisor teeth, simple pressure on the bulb will send the application directly into the larynx. Orthoform tablets may be dissolved in the mouth shortly before eating. In the event of failure of these to relieve the dysphagia then the alcohol injections are next in line.

For the cure of the ulcerative process the iodine treatment of Pfannenstill; or scarlet red; the galvanocautery or the curette, resort being had to extreme surgical measures last of all.

As so much may be done for these patients every properly equipped sanatorium should have a competent laryngologist in attendance as should also every tuberculosis clinic, for the early detection of the presence of this so justly dreaded invader.

EMIL MAYER.

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Las Vegas Hot Springs.—San Miguel County, New Mexico.

POST-OFFICE.—Las Vegas Hot Springs.

ACCESS.—Viâ Atchison, Topeka and Sante Fé Railroad to Las Vegas, thence by branch line six miles to springs. Through Pullman sleeping-cars pass Las Vegas twice a day in both directions. These springs are situated upon the southeastern slope of the Santa Fé range of the Rocky Mountains at an altitude of 6,767 feet above the sea-level. They are about forty in number, and vary in temperature from ice-cold to very hot, the thermal springs ranging from 110° F. to 140° F. The following analysis of the waters of the largest of the latter, flowing, 1,250 gallons per hour, was made by Dr. Walter L. Haines, professor of chemistry at Rush Medical College, Chicago:

SPRING NO. 6 (LAS VEGAS HOT SPRINGS).
ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	0.89
Magnesium carbonate	.15
Sodium carbonate	8.38
Potassium carbonate	.28
Sodium sulphate	3.35
Sodium chloride	14.68
Silica	3.50
Alumina	.10
Volatile and organic matter	.32
Lithium carbonate	Traces.
Sodium bromide	Traces.
Total	31.65

In its chemical composition this water resembles in many respects that of the famous hot springs of Toeplitz, in Austria. The baths are said to have accomplished excellent results in rheumatism, gout, and diseases of the skin and lymphatic system. Mud baths are a special feature. This vicinity partakes in a large degree of the magnificent climatic conditions prevailing in New Mexico. The average humidity of New Mexico, as shown by the recent reports of the United States Signal Service, varies from 29 to 43 per cent. according to locality—as compared with 72 per cent. for New York City, 73 per cent. for New England, 74 per cent. for the Middle Atlantic, and 79 per cent. for the Southern Atlantic States. The climate here is peculiarly adapted to persons afflicted with hay fever, bronchial asthma, and most forms of throat and lung diseases. The rarity of the air, caused by the high elevation, renders this region un-

favorable for cardiac affections. Among the many attractions surrounding the Las Vegas Hot Springs may be mentioned the magnificent mountain scenery, the beautiful drives, and the unrivalled opportunities for fishing and hunting. The hotel and bath houses were closed about nine years ago, but efforts are being made to open the place again.

EMMA E. WALKER.

Latah.—*Synonyms:* Jumping, Bah-tschi, Meriatchenye, Myriakit, Sakiltatar, Mimicismus, Echomotism.

Latah is a mental condition in which uncontrollable action follows suggestion and seems to develop in people who through ignorance and environment of others with the disease give way to and encourage it. The list of contributors to the literature given by Castellani and Chalmers in 1913 is O'Brien in 1883, Gilmour in 1892, Van Brero in 1895, Ellis in 1897, Gerrard in 1904, Manson in 1907, Fletcher in 1908, Plan in 1911, and Abraham in 1912.

The disease is found in the Malay Peninsula, Java, Sumatra, Siam, Burma, Phillipine Islands, Siberia, North America, and Abyssinia.

The cause of the disease is mental weakness accompanied by example set by others. Children may have the disease but it is only after many years of cultivation or rather giving way to it that the condition is marked. Malay blood and therefore inferior higher centers seems to favor the prevalence of the disease among people.

A somewhat similar disease is seen in the southern negroes (U. S.) and the least intelligent whites sometimes intimately associated with them. Such persons are called "goosy." In Europe there are sometimes found what are called "Barkers," "Jumpers," and "the Jerks." Feeble higher centers and suggestion by association with others who have the condition, weakness, or disease, are the important etiological factors. It is a question whether the state of excitement through which certain people of higher mental development as well as the lower class pass during religious revivals may not in fact be a species of this condition, known as Latah in the feebler minded Malay. They have been known to "shout" and carry on in a most ridiculous way during such excitement. The present writer remembers when a boy to have gone to churches in the country in Mississippi where "shouting" had occurred with the sole purpose of getting to see the performance, but he was never successful.

The symptoms of Latah are so different in different parts of the world that it would be impossible to describe them all here. With the Malay there are two varieties of the complaint. In one, sudden shock, such for instance as a sharp noise or a sharp blow is followed by violent action of one kind or another and the vilest language of which the individual may be ashamed afterward. In the other, at the time of the shock or excitement the individual sees the action or movement of another person and falls in to imitating the movement. The latah is unable to control himself for some time and often keeps up the movement until completely exhausted. It is explained that the sudden action inhibits the higher centers and produces reflex imitation of the action which excited it. The memory seems to be lost for the time but insanity is not any more likely to occur in one subject to latah than in one not so affected.

Change of environment and education improve and cure many subjects. Sometimes they cure themselves by resisting the temptation to give way.

C. C. BASS.

Lateral Curvature of the Spine.—*Synonym:* Scoliosis. The various definitions of lateral curvature fail of their object in so far as they limit themselves to a description of its superficial features and do not emphasize those which are fundamental to the condition. All distortions of the trunk cannot be classified as scoliosis, but only that type of deformity which has for its distinctive feature a permanent asymmetrical distortion of the spine, in rotation and in lateral deviation, resulting in an asymmetry of the two lateral halves of the trunk. Lateral curvature may therefore be defined as a permanent asymmetrical distortion of the trunk in which the spine plays the fundamental part.

In its initial stages the deformity differs from the various normal positions of the figure only in the origin of these positions and in the permanency of any given one of them. In the more advanced stages the distortions become more pronounced in character, and their permanency or resistance to correction is caused by the alterations in structure consequent upon the adaptive changes which occur during growth.

FIG. 3700.—Experiment Showing Lateral Bending.

The movements of the spine which are in a pure anteroposterior plane do not produce asymmetry of the figure since the two halves move symmetrically. The movements of the spine which result in asymmetry proceed from lateral bending and torsion, effecting those changes in figure which would come from a displacement of the symmetrical position of any part of the two halves. The changes which occur in lateral curvature may be classed as, first, the spinal or those affecting the spinal column, which may be designated as primary, and, second, the figure contour changes or those which result from the displacement of the spine, and which, therefore, may be regarded as secondary.

We have already said that these changes, both spinal and contour, which occur in lateral curvature, are, in the initial stages, normal in range and direction but abnormal as to origin and permanency. We will now describe what these changes are; and first, as to range and direction.

The two primary changes which occur, namely, lateral deviation and rotation, are distinct and can be studied separately, although clinically they are always found associated. Since, however, they are not always associated in the same relative degree (whence result the various types of curves), it is better for clearness of description to consider them independently.

Lateral Deviation.—The lateral deviation is the bending to one side of the spine, either throughout its entire length or in a limited section. If lateral deviation could be regarded as a pure movement, all parts of the vertebra would be carried equally to the side, so that a line drawn through the center of any of the vertebræ would be in the direct anteroposterior plane of the body. This lateral deviation may affect any portion of the spine and to any degree, or it may affect two different portions of the spine each in a different degree and in a different direction. It resembles lateral bending in that it is a movement in the lateral plane; but differs in that it is a bending of a portion of the spine on itself without necessary displacement of either extremity, whereas lateral bending is a bending of the spine to one side on the pelvis, away from the median plane of the body.

Rotation.—Rotation is a turning on the vertical axis of all the vertebræ participating in the curve; the amount of displacement for each vertebra being different and being greatest at the middle of the curve. The axis of rotation is in about the posterior third of the vertebra, the movement of the anterior part of the vertebra being in the opposite direction from that of the posterior. The length of the anterior portion in front of the axis of rotation being greater than the posterior, the amount of deviation from the normal of the bodies is necessarily greater than that of the spinous processes. The rotation of the spine necessarily involves those parts of the skeleton which are attached to it, as the ribs, and the result may be seen in the shape of the thorax. If rotation occurred as a distinct movement, the axis of its rotation would then remain in the center of the trunk, the bodies would describe a curve upon one side and the spinous processes a curve of a smaller arc on the other. This rotation, like the

Fig. 3701.—Experiment Showing Rotation.

lateral deviation, may affect the whole of the spinal column, or only a portion, or two sections in different directions.

Although these two distortions, rotation and lateral deviation, may be studied independently, it must be remembered that clinically they are always associated. Moreover, they are always associated in the same relation, in that the rotation of the bodies is always toward the same side as the lateral deviation of the column.

It is necessary to remember, in relation to rotation and deviation, that the direction of rotation of the bodies is in the same direction as the lateral deviation of the column, and that the direction of rotation of the spinous processes is in the opposite direction, therefore the amount of distortion of the spinous processes is the least of any portion of the spine, while that of the body is the greatest. It can be expressed as follows: The amount of deviation of the bodies is equal to the lateral deviation of the axis of the column plus the rotation, and the amount of deviation of the spinous processes is equal to the lateral deviation of the axis of the column minus the rotation.

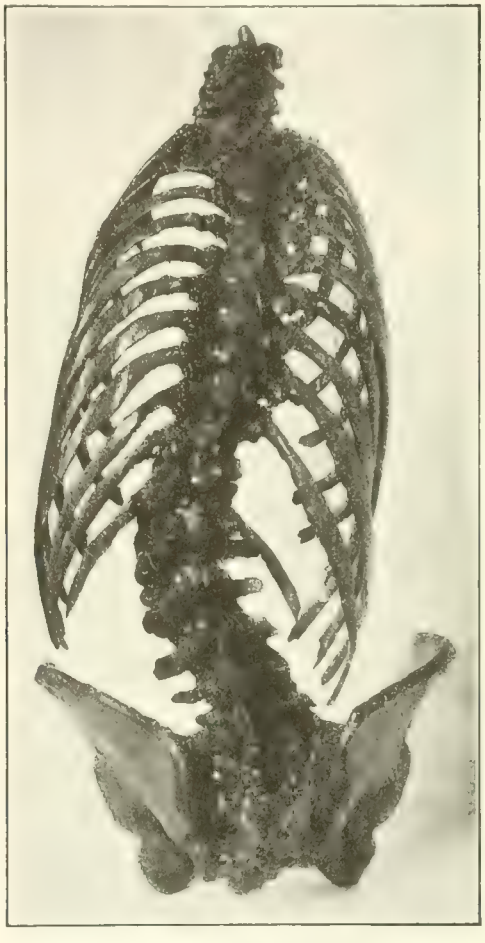


Fig. 3702.—Posterior View of Scoliotic Spine. (Warren Museum.)

Although these two movements are always associated clinically they are not associated in any definite degree or proportion, and since they may affect any part of the spine to any degree and may be associated in different degrees, there is allowed the widest range of variation in the resulting types of curves.

The Secondary or Contour Changes.—The secondary conditions cannot, like the primary, be studied as distinct and definite distortions, since they consist of the displacement of the parts of the trunk and their very great variety does not admit of a definite enumeration. It is better, therefore, to study these with reference to the direction of displacement of the different parts which may be affected. The trunk may be studied in its lateral plane by the position of the head, including the shape of the neck, by the position of the shoulders and scapulæ, and by the line of the thorax, etc.; and in the horizontal plane by the relative prominence of the back at any level, as may

be manifested in the dorsal region by the shape and position of the ribs, and in the lumbar by the belly of the erector spinæ muscle. In this way we may map out the schematic method of examining the trunk as follows: The method represents a definite route for examination, taking in turn each part which may be displaced, as well as the direction of its possible distortion

A. Head and neck (as shown by):
  (*a*) Line of trapezius.
  (*b*) Position of head.
  (*c*) Sternomastoid muscle.
B. Shoulders.
  (*a*) Level (vertical plane).
  (*b*) Forward inclination (horizontal plane).
C. Scapulæ.
  (*a*) Level (vertical plane).
  (*b*) Distance from the spine (lateral plane).
  (*c*) Distance from the middle of body (lateral plane).
  (*d*) Prominence (anteroposterior plane).
    (1) Position relative to spine (angle of inclination.)
    (2) Position relative to underlying ribs.

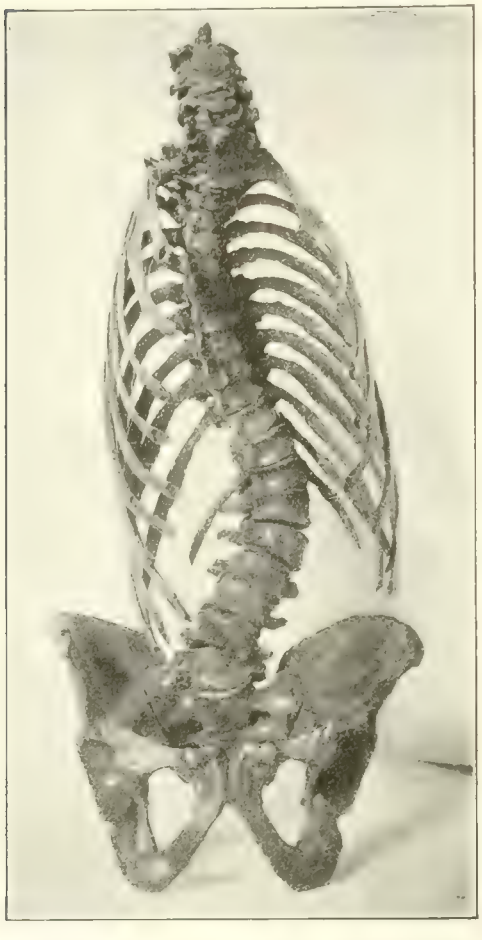


Fig. 3703.—Anterior View of Scoliotic Spine. (Warren Museum.)

D. Line of thorax.
  (*a*) Shape of side of thorax and waist.
  (*b*) Arm-waist angle.
  (*c*) Relation of lower ribs to crest of ilium.
  Prominence of two sides.
  (*a*) Dorsal region (ribs).
  (*b*) Lumbar region (transverse processes of vertebræ and erector spinæ muscle.)

The above description is equally applicable to changes occurring in the normal or in the abnormal condition, since in the normal the same asymmetrical changes, such as lateral deviation and rotation, may be produced by the usual and ordinary movements of the spine.

These distortions become abnormal, and are classed under true lateral curvature only when occasioned by some structural change, even if very slight, of the spinal framework, and which come either from some congenital defect as the starting point of increasing deformity, or from the malpositions habitually assumed. These changes in structure are found in bone, ligaments, and muscles, and in the main are the result of the altered relations of the parts consequent upon the distortions of lateral deviation and rotation. Since these changes occur during the formative period of growth and conform to those malpositions of the spine which are constantly assumed, they illustrate the law that, during growth, structures adapt themselves in shape to positions in which they are held.

These structural changes may be considered as they are seen in the bones, the ligaments, and the muscles.

Changes in bone are seen in the thickness of the bodies of the vertebræ, these being wedge shaped instead of having an even thickness; there is also a twist in the anteroposterior axis, so that a straight line drawn through the vertebra does not intersect it into two equal halves. Accompanying these changes in the vertebræ are alterations in the shape of the ribs, consisting of an increase of the angle behind on the side of rotation, and a flattening of the corresponding portion on the opposite side, with an increase in prominence in front, so that the long diameter of the chest is oblique instead of lateral.

Accompanying these changes in the shape of the bony parts of the trunk are the adaptive changes in the length of ligaments, which become shorter on the concave, and longer on the convex sides, thus serving to hold the spine in this position. It is also to be remembered that after long continuance in malpositions there are adaptive changes in the length of the muscles.

Etiology.—Many theories have been advanced from time to time in reference to the etiology of this condition, no one of which is sufficient, and yet each is of value in that it suggests some of the conditions which are active either in the initiation or in the increase of the curve already developed, and a mention of some of these is of importance to show the stages through which this part of the subject has passed. As for instance, that advanced by Hueter and Engell, of unequal growth of bone; by Guerin, of the spasmodic action of muscles; by Eulenberg, of unequal action of muscle; by Rosa and Volkmann, of the influence of superincumbent weight.

The etiology of lateral curvature is necessarily a complex one, and the condition must be regarded as a vice of development, and the study of its etiology is a study of the influential factors which result in the development of the asymmetrical instead of the symmetrical form. It is a well-recognized fact that bone during the period of growth, or in certain pathological states, may be moulded into various unusual shapes by pressure; and therefore if we have, as in lateral curvature, a condition of plastic bone coupled with a position of distortion of the spine and appendages, either constantly or so frequently assumed as to exert an unequal pressure upon the vertebræ, we have conditions which may result in asymmetrical growth and the formation of a permanent deformity.

Recognizing the fact that one of the essential factors in the development of lateral curvature is the presence of plastic structures, the further consideration of the etiology of this deformity is the study of the conditions which result in the assumption and maintenance of any one malposition by the individual.

The factors which bring about malpositions may be divided into (1) those in which there is a physical defect as an apparent cause, and (2) those in which there is no sufficient physical defect, the deformity resulting rather from many conditions of environment which tend to promote bad attitudes. When the habit of malposture is once established, the factors of muscular weakness and superincumbent weight have a tendency toward exaggerating the condition.

Fig. 3704.—Lateral Curvature after Empyema.

These etiological conditions may be tabulated as follows: 1. Physical defects, such as (*a*) paralysis, (*b*) loss of limb, (*c*) empyema, (*d*) torticollis, (*e*) static defects, (*f*) defective vision, (*g*) structural developmental defects of the vertebral column, etc. 2. Habits of posture as influenced by (*a*) occupation or reaction, (*b*) general environment (school desks, etc.), (*c*) effect of clothing, etc. 3. Muscular weakness, and 4. Superincumbent weight, when combined with the above-enumerated conditions.

Among the physical defects may be mentioned those of loss of arm, causing unequal distribution of weight; thoracic disease, as empyema, with incomplete lung expansion, resulting in the unequal development of the two sides of the thorax; static condition, as short leg, giving unequal pelvis; paralysis, giving unequal muscular support, etc.

Among the influential causes classed under the grouping of physical defects is the most important one, that of the congenital spinal anomaly, which exerts a powerful influence on the symmetrical growth of the vertebræ during the periods of most rapid growth. These peculiarities or defects of development which consist of numerical variations of the spinal segments were first described by Rosenberg. The importance of these defects as an etiological factor in the development of lateral curvature was shown by Böhm (*Boston Med. and Surg. Journal*, Nov. 22, 1906). He demonstrated that these numerical variations were associated with or manifested by asymmetrical defects, either in the rib attachments, in the shape or position of the articular facets, in the partial development of a whole vertebra, or in the transverse processes of the last lumbar vertebra with the ilium.

The importance of this fact cannot be overestimated, for during the developmental periods of growth the asymmetrical growth of the vertebræ will necessarily lead to a distortion of the whole spinal column. In corroboration of this theory Böhm found in a series of scoliotics examined a very large majority showing some form of this numerical variation.

More recently Adams (*Boston Med. and Surg. Journal*, May 21, 1914) has found variation in the articulations of the fifth lumbar vertebra and sacrum. These abnormalities are variations in the size and shape of the articular facets, or in the direction in which the facets point. The primary fault is apparently in some cases due to the failure in the fusion of the pedicle of the vertebra. These defects allow a slipping forward of one side of the fifth lumbar vertebra, which is equal to a rotation on the first sacral segment. Adams has very clearly shown that as the inclination of the supporting surface of the upper sacral vertebra is placed at a forward angle of forty-five degress and plus, and as the anterior portion of the body of the fifth lumbar vertebra is much thicker

Fig. 3705.—Showing the Conditions in a Structural Case of Lateral Curvature of the Spine.

than the posterior, that any rotation of the fifth lumbar on the sacrum leads to a very decided inclination of the vertebral column above. He has also found, in corroboration of this theory, a very large percentage of these anatomical defects in the scoliotics examined.

Among habits of posture are such as standing on one foot, standing or sitting in one position, exercise in a constantly bad position, continued use of one arm,

etc. As an illustration of faulty environment may be mentioned the improper arrangement of clothing, making undue pressure upon one or the other shoulder, position of the child's desk with reference to the teacher, improperly constructed school seats, etc.

In the conditions of health and muscular tonicity one finds the habit of malposition much less frequent

Fig. 3706.—Showing the Condition in a Postural Case of Lateral Curvature of the Spine.

than in the condition of muscular tire and muscular weakness. It is not to be expected that a young and growing child shall always preserve a correct posture, but, on the other hand, a child does not habitually assume any one particular bad posture without some cause, and so for this reason the factor of muscular weakness becomes etiologically important when combined with those conditions which induce malpostures.

In the same way the factor of superincumbent weight acting upon a spine already in a position of deviation and rotation, furnishes a powerful additional force to the increase of the distortion already established.

The etiology can, therefore, be graphically represented in the following diagram:

Physical defect. Habits of position.	Faulty attitudes.	Lateral curvature.
Growing periods. (Plastic stage.) Abnormal bone. (Rickets.)	Soft bone.	

Classification.—The various curves are frequently grouped according to the location, the extent of the curve, and whether the spine presents one or more areas of distortion. Lovett (Lateral Curvature of the Spine and Round Shoulders) has grouped them according to this plan, as follows: A total scoliosis or one in which the spine forms a gradual curve to one side without marked rotation or compensatory curves. Many of these cases appear to be postural but are found to show changes of structure upon careful examination. Structural scoliosis (organic or habitual scoliosis) which term is applied to changes in which a structural change in the vertebræ has taken place; rotation is always present. The structural curves are either simple or compound—simple when there is no compensatory; compound when there is more than one curve present. A convenient classification of these cases is based upon the stage of their development, since the process is a continuous one and the case represents like conditions in all the phases of its course, showing a difference only in the degree of severity. The record of the case gives the location and character of the distortion, and it is not necessary, therefore, to resort to an arbitrary classification in order to define the location of the deformity. Although this division into stages must be more or less arbitrary, since the condition is progressive, yet it enables one to record in general how much of a change has taken place, and is of value as an indication for treatment as well as in the prognosis.

We may therefore divide lateral curvature into three stages: 1. The postural, in which the curves are flexible and there is no evidence of osseous change; 2. The structural, in which the curves are flexible

Fig. 3707.—Showing the Condition in a Severe Fixed Case of Paralytic Origin.

but in which there is an evident osseous change; (3) The fixed curves of marked severity, in which there is little or no flexibiltiy.

The conditions found in the different groups are: 1. Postural; showing (*a*) slight changes in contour, (*b*) slight degrees of lateral deviation and rotation, (*c*) easy correction or overcorrection, (*d*) asymmetry in flexibility. (2) Structural; (*a*) pronounced changes in

contour outline, (*b*) permanent lateral deviation and rotation of the spine, (*c*) correction and overcorrection not possible, (*d*) evidence of bone changes. 3. Fixed; (*a*) marked contour changes, (*b*) extreme degrees of lateral deviation and rotation, (*c*) correction not possible, (*d*) evidences of extreme bone changes, (*e*) inflexibility.

Age of Appearance.—Congenital cases have been reported. They are not common, usually present some anomalous defect, when studied by the *x*-ray, and are associated with antenatal rickets. A certain number of instances are brought to the physician's notice in infants of the age of a few months. In the majority of these cases it is found that the deformity is caused by holding or carrying the child in one position, so that it is practically moulded into this shape. As an instance of this may be mentioned the case of an infant of six months, with a distinct lateral curve, which was apparently caused by keeping the child during the greater part of the day propped in the corner of a sofa, the curve of the spine fitting the position it assumed while in this place.

In the majority of instances the cases are brought to notice during the period of rapid growth. Different statistics which have been collected with reference to the time of appearance apparently group themselves into two periods, that of the first growth, about the age of eight or nine, and that of the second, between the ages of eleven and fifteen, depending somewhat upon the sex. Undoubtedly many of the cases really date from a time previous to their discovery, but since an increase is more likely to occur at a time when the structures are in the most plastic condition, and at a time when the strength of the child is taxed by the process of growth, it is natural that the affection should be first recognized at such time. One may look for the rapid development of the curves during these times of growth, and for a decrease in the rapidity of their progress after the period of growth is over and the bones have become hard.

Influence of Sex.—By far the largest number of cases are found in girls, and this is undoubtedly due to their more restricted environment, to their less general participation in athletic exercises, and to their weaker muscular condition. The deformity is often seen, however, in robust boys, frequently among those who are devoted to a special form of athletics, and such cases often develop to an unusual degree of severity.

Symptoms.—The subjective symptoms in this affection are, as a rule, slight, and more frequently there are none. They are sometimes seen in the severer cases in which the unequal distribution of weight would seem to play a factor, giving a greater muscle strain and muscle tire. When present they usually consist of easy fatigue and irritability, and are such as would ordinarily accompany a general muscular insufficiency, rather than a particular spinal lesion. At times, however, in cases with very marked deformity, pain referred to the concave side is a troublesome feature.

Record.—In the recording of lateral curvature there are two features to bear in mind, first, the changes in the contour of the figure caused by relative displacement of parts, and second, the changes which are seen in the spine and the bony framework of the trunk. It is best to keep this distinction in mind, since in the one we need only graphic reproduction to show the character and general amount of such change, while in the other we must take as accurate measurements as possible to show the amount of departure from the normal. Records may be taken in either the standing or the lying position, each having its advantages, and each being of value both for itself and for comparison with the other.

The upright position, in that it is the usual position and represents the greatest curve, gives the more practical record. On the other hand, the conditions in standing bring in the element of fatigue, muscular action, voluntary effort, superincumbent weight, etc. —factors which are more liable to vary at subsequent measurements. The recumbent position gives a record under conditions less liable to variation and easier to reproduce. The curve is, of course, least marked when the patient assumes this position, but the record is for this very reason not the one which represents the real deformity. The difference in measurements taken by the two methods is approximately an indication of the amount of flexibility.

The problem is to put into some graphic form the various changes which occur, and methods too numerous to mention have been devised for this purpose. All methods have an element of error and bring in the factor of personal skill, and since it is a measurement, not of a mathematical certainty, but of a condition changeable within certain limits, it is well to have a number of forms of graphic representation from which an average may be taken. All the methods may be gathered under a few groups according to the principles which were used. These groups are: (*a*) Measuring machines, (*b*) outline tracings, (*c*) photography, and (*d*) measurements.

Measuring Machines.—Of these that of Zander may stand as the type, being the most complete. The method used in machines of this kind consists in some means of fixing the patient in position by clamps to prevent any movement while the measurements or tracings are being taken, and some device for recording by measurement the relative position of the parts, and transferring the results in such a way to paper as to have a reproduction in drawing of the trunk in either a full or a reduced size. These machines are complete and accurate, but they are expensive and demand some skill in manipulation, which is particularly needed in any device using clamps to fix the patient, the danger being that of displacing the patient from his natural position.

Outline Tracings.—Of this the pantagraph is the best illustration and consists of a device by which the movements of the recording pencil drawn over the patient are reproduced on paper. Other forms of the same method are that of the old-fashioned lead tape, and such tracing machines as that of Weigel which is used only for rotation. These have the advantage of being simple and inexpensive and of not requiring any special skill in their use, but movement on the part of the patient when the pencil is drawn over the skin is apt to impair the accuracy of the record.

Photography has certain advantages to recommend it for general use. It gives all the outlines of the figure and the deviation of the spine which is obtained by other methods. It enables the record to be taken without the clamping of the patient in position, and it has the advantage of rapidity so that the element of muscular fatigue does not come in. If a screen is placed behind the patient, this can also be used for the measurement of such deviations as are in the lateral plane. It is necessary, however, to have the patient stand directly in front of and perpendicular to the camera, otherwise the view is a combination of the back and side positions. (Fig. 3708.)

An efficient and simple method of recording by photograph has just been described by Osgood and Bucholz (Fig. 3709). The patient is placed in a frame, both anterior-superior spines and both shoulders against four adjustable pelots, thus ensuring the patient's position of a right angle to the camera. A stereoscopic camera is used, taking the two views at one time. The patient, the screen, and the camera have fixed positions, so that photographs in series have a fixed basis for comparison. A plumb line is dropped from the top of the screen to give the vertebral line for measurement. To record the rotation the patient is made to lean forward, the angle of inclination governed by spirit level, to an agreed upon angle. The photograph thus gives a cross-section view, at

the same point at each record. The method commends itself for its thoroughness and simplicity.

The method of *measurement* is restricted to the recording of the displacement of such bony prominences as can be measured, and is, therefore, practically a measurement of the deviation of the spine as is shown by the line of the spinous processes. This can be measured either as the deviation of the spine from a line drawn between its two extremities—as, for instance, the seventh cervical vertebra and the fold of the buttock, showing the deviation of the spine from its own axis; or it can be measured as the deviation from the plumb line intersecting one extremity of the spine, showing both the deviation of the spine and the amount of displacement of the shoulders on the pelvis.

A record is made of the point at which the spine leaves the straight line, its point of maximum departure, and its point of return; and in the case of a double curve the lower one is measured with reference to the same points. These points may be designated either by the number of the vertebra or by measurements in distance from any fixed point, as, for instance, the seventh cervical vertebra above or the level of the posterior spines of the ilium below. The advantage of this latter is, that in those cases in which it is difficult to count the spinous processes, one has a more ready and practical method of comparing subsequent tracings.

Fig. 3708.—Record by Photography with Screen.

The methods used by different individuals must necessarily vary according to the means at hand and to the individual's preference. When the more expensive and accurate machines can be had there is no question about the advisability of their employment; otherwise it is best to use the means at hand which are most applicable and with which the individual is most familiar.

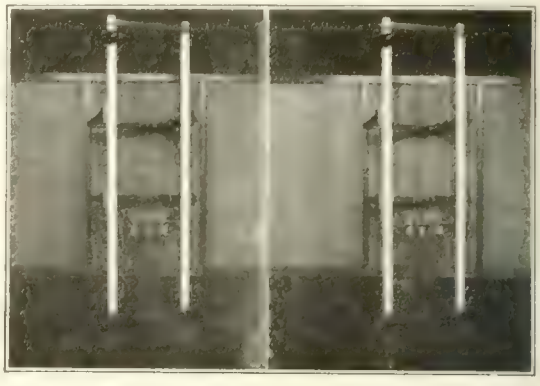


Fig. 3709.—Stereoscopic Apparatus for Photographing Lateral Curvature. (Osgood and Bucholz.)

As an illustration of a practical method the following may be given: Record the outline changes by photography, either with or without the screen. Measure the distortion of the spine from either the plumb line or the midline drawn between the two extremities. In either case the point of departure from the straight line is noted and recorded, both by its distance from a fixed point, as, for instance, the seventh cervical vertebra, and also by the number of the vertebra; the point of greatest deviation of curve and the point of its return to the midline are also to be recorded in the same terms. If two curves exist, the second is measured in the same way as the first. These measurements are taken with the patient in the erect and in the recumbent positions, the difference between the two results indicating the amount of natural flexibility of the curve. Rotation, as shown by the prominence of the ribs, is recorded by outline tracings taken perpendicular to the horizontal, reproductions of which in stiff cardboard may be verified by application to the body of the patient. Rotation also may be recorded by the goniometer, a machine for measuring the angle of inclination of the most prominent and of the most depressed portions of the trunk at any given section.

Treatment.—The rational treatment is based upon the application of certain principles to meet needs found in the individual case. In general these needs are uniform and may be said to be, first, an increase in flexibility, so that a straighter position is possible, and second, the maintenance of this improved position by whatever means is most practicable, whether it be that of muscular development, or retention by apparatus, or both.

The treatment should always have a definite object in view and involves the consideration of (1) the various needs to be met, and (2) the means by which these needs may be met. The application of the principles to the individual case will necessarily vary with the facilities at hand.

The measures which may be used in the treatment of lateral curvature are: (1) Preventive. (2) Forcible

correction for the increase of flexibility; (*a*) mechanical or passive, (*b*) gymnastic or active. (3) Gymnastic exercise for muscle building; (*a*) for definite weak muscle groups as in paralysis, (*b*) for general improvement of muscle strength (muscle insufficiency), (*c*) for readjustment of muscle control. (4) Apparatus; (*a*) preventive of faulty attitudes, (*b*) retentive, by the application of pressure to retain improved positions; (*c*) corrective application of force constantly applied to maintain correction, as plaster jackets applied with forcible correction.

Preventive Measures.—These may be considered with reference to the correction of any physical defect, such as short leg torticollis, etc., since it is necessary to counteract the influence of any such existing permanent factor. Also with reference to the correction of any conditions in the environment of the child, as improper clothing, school desks, etc., which will tend to induce habits of malposture. In this connection the question of school seating in its effect upon the growing child deserves especial consideration.

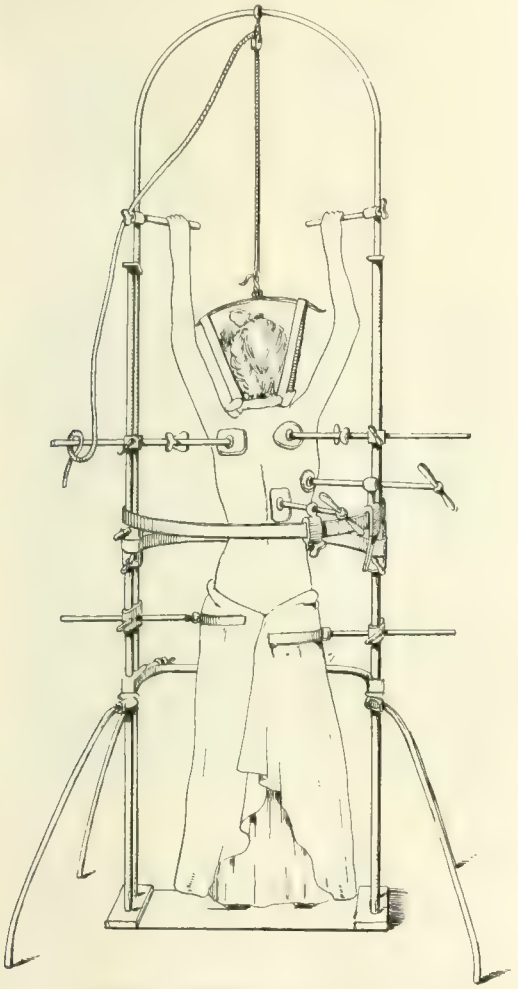


Fig. 3710.—Modified Hoffa-Schede Appliance for Correction by Pressure.

Forcible Correction.—Forcible correction has for its object the increase of flexibility in definite regions of the spine and in a definite direction, in order to make possible a straighter position of the spine. The principle is the same as that employed, to an exaggerated degree, by contortionists and stage dancers, and is based upon the fact that structures which are rhythmically stretched become lengthened.

The mechanical (passive) correction has for its principle the application of pressure through some mechanical force, and in that it eliminates the body weight and muscular antagonism it has the advantage of being directed more definitely toward ligamentous stretching, and it also allows the application of the force more accurately, both as to its direction and as to the amount used. An example of machines of this kind is that of the screw pressure first originated by Hoffa. In such the patient is partially suspended, the hips and shoulders are held by clamps, and the pressure is applied over any part of the trunk in any direction that is desired, with counterpressure exerted in front at the proper places so as to exert a lateral or rotating force. It is necessary in this that the two ends of the curves shall be fixed as nearly as possible, that there shall be a certain amount of suspension, and that the rotation pressure shall have its counterpoints in such places as shall not cause compression of the chest. (Fig. 3710.)

The employment of apparatus for increasing flexibility has been carried to the point nearest to perfection by Schulthess, who has devised numerous machines for the application of pressure, some of which employ the principle of the pendulum movement in which the weight of the body is used as an additional force either to make pressure or to bend the spine at any desired point.

Gymnastic (active) correction involves forcible muscular action combined with gravity, so that the momentum of the weight of the body is used as a force to carry the bending beyond its natural limit. This has a wider range of practical usefulness in that it does not require a complicated apparatus. On the other hand, its application is less localized to any particular part of the spine, and it is less manageable, as regards both the amount and the direction of its force.

In either of these two methods the object is to increase the flexibility of the spine in any special area so as to increase the amount of possible bending toward the position of correction.

Gymnastic Exercises.—These may be given for the strengthening of definite weak muscle groups, for general muscular improvement, or for readjustment of muscular control. For the accomplishment of this, gymnastic exercises may be given either without apparatus, dependence being placed upon the free movements of the body and forced muscular contraction, as in the Swedish methods, or with apparatus—weights and bars, bells, etc., but it would seem that less depends upon the method which is employed than upon the use that is made of it. In other words, the character of the work is of more importance than the method chosen.

Many other methods of exercises have been used and the success attending them is very largely dependent on the amount of care and the persistency with which these are carried out, as well as the adaptability of this form of treatment to the special case. Among these are to be mentioned those of Roth; the creeping exercises of Klapp; the forcible exercises of Teschner, etc.

Gymnastic Exercise in Correction.—By this term is meant that form of exercise in which the patient is taught a correct standing position, and is then made to hold such a position during the time of the exercise, which is discontinued as soon as this position is lost.

It is a recognized fact that the muscles become accustomed to positions in which they are used, as is seen in those professions in which some malposition is assumed, and the muscles become either shortened or lengthened by such use. This is also seen in cases of lateral curvature when the individual has become so accustomed to the position of distortion that when placed in a straight position he at once expresses himself as feeling "crooked." If all exercises are carefully

carried out in a corrected position the results will necessarily be more beneficial.

The method of exercising in a corrected position which is artificially maintained, either by mechanical appliances or by special postures, has the disadvantage that it necessitates an artificial position on the part of the individual while exercising, and thus does not help in the training of the maintenance of the improved position by voluntary control.

Fig. 3711.—Lack of Symmetry in Contour in Lateral Curvature of the Spine.

The position of correction, however, may be a voluntary one maintained by the patient's unaided effort, with the object of training the muscles to a maintenance of the desired position. At first the effort of holding an improved position must be purely a voluntary one, but by education, through the constant exercise in this effort, it becomes more involuntary, and in consequence the position is maintained with greater ease.

The kind of gymnastic exercise used for the development of the muscles is not so essential as the character of the work. One may use the lighter forms of gymnastics, depending upon the body movements with forced muscle contraction, or the lighter forms of weights and pulleys, or, if desired, the severer forms of exercise with heavy weights, with the aim of accomplishing the muscle development more rapidly. The essential of all is that the position of self-correction or overcorrection should be held during the time of the exercise, and that the exercise be discontinued when the patient is so tired that it is impossible to keep it longer.

Method of Conducting the Exercises of Self-correction.—It is essential to correct as much of the faulty position as the patient's flexibility will allow, which is done by observing the amount of the displacement of the head, shoulders, and scapulæ, and the sagging of the trunk in the lateral plane, and then teaching the child to take the improved position. This is done not only by instructing the child in the points to be corrected, but also by manually placing him in a better position. It is a fact that a better position can be held than it is possible to take unaided.

The various methods of conducting a case are so numerous that it would be impossible to give a detailed description of them all, and, therefore, in this article an attempt will be made to describe only one which will serve as an example of the corrective form of exercise.

The first step is the taking of the improved position, and this may be accomplished by first encouraging the effort toward straightening the spine, by telling the patient to make himself tall, which must be done without raising the shoulders. Then, in order, the position of the head, the level of the shoulders, the relative position of the scapulæ, and the displacement of the shoulders over the pelvis are corrected, and the patient is encouraged to hold this improved position by his own effort. After being allowed to relax, he is again put in the same position and exercises are given while the correct position is maintained. Care is taken that as soon as the child relaxes from this position in any particular the exercise is stopped, until the position is again resumed.

The first grade of exercises in the position can be taken with the arms moving in the lateral plane which displaces the position least of all, and bells may be used or manual resistance made according to the patient's strength. The next stage consists of exercises in the forward as well as the lateral plane, the two being combined, which necessitates a greater effort on the part of the patient to hold the back in the new position. The third stage consists in having the patient change the position of the feet, as in the Swedish fall-out position, so that the center of gravity

Fig. 3712.—Showing Effect of Effort to Straighten the Spine.

of the body is changed, and then go through with the same exercise with the arms and with the moving of the trunk on the pelvis, and returning to the standing position while holding the back in correction.

It is seen that, at first, a patient is able to hold by his own effort a much better position than that which he is able to take voluntarily, but it soon becomes possible for him to take this same position and to hold

it himself during the exercise. It is necessary that the person should not keep the muscles of the whole trunk rigid during the exercise, but should localize the effort upon the spine. To this effect the patient is made, between any two forms of exercise, to relax all muscles with the exception of those movements of each exercise he makes an additional effort to straighten the spine.

Apparatus.—Apparatus has for its object either the prevention of faulty attitudes, or the retention in improved positions, or else the application of a force constantly exerted to maintain correction beyond the point of flexibility.

The use of apparatus in the first two instances is to supplement other treatment. If one could be sure that, after an increase of the flexibility by the methods of forcible correction, the improved position would be held by muscular action, there would be no need of further retention. If, on the other hand, exercise treatment can be carried out but a short period of each day or less, and during the remainder of the time the child is continually assuming its habitual malpositions, there is then evident need of some means of retention during the interval.

When used for the first object, that of preventing faulty attitudes, the apparatus should be very simple, and no attempt should be made to exert pressure, its use being rather as an aid or as a reminder. It may be that only a crutch, fastened to the child's waist to prevent the dropping of the shoulder, may be necessary, or a light upright to prevent the child from sagging either in the anteroposterior or in the lateral direction. In any case it should be adapted to the individual need.

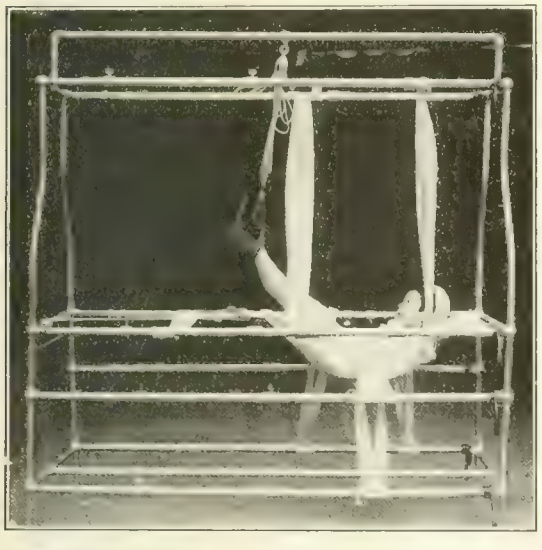


Fig. 3713.—Abbott Frame for Application of Forcible Plaster Jackets for Lateral Curvature.

When applied for the second object, that of retention, the aim of the apparatus is to hold the patient in a better position than he can maintain by his own unaided efforts. In these cases as much force as is compatible with the patient's comfort is used and is applied either in the anteroposterior or the lateral plane. In this the pressure must always be made over the points of greatest curve, and there must be two points of counterpressure on the opposite side well above and below the limits of the curve. In other words, counterpressure in the concavity of the curve must be carefully avoided.

Apparatus for the object of correction consists of the employment of a plaster jacket applied in the over-corrected position. Such a method is applicable in the treatment of patients who come from a distance, or who for other reasons are unable to carry out a definite and continuous treatment, and it is also adapted to those cases which require more forcible stretching than can be carried out by the gymnastic method. This method as has been practised in the past, consists in the application of a jacket while the patient is in either the recumbent or the upright position, pressure being made over the points of convexity by straps or by pads, which are attached to movable screw rods, while by means of clamps the hips and shoulders are fixed in the desired position and counterpressure is applied. The method has had many firm advocates, but radical results have not been claimed, the amount of improvement in most of the cases was not encouraging, and the treatment was long continued. These jackets were applied in the extended or slightly hyperextended position of the spine. A very great advance has now been made by the work of Dr. E. G. Abbott (*N. Y. Med. Journ.*, June 24, 1911; Apr. 27, 1912; July 6, 1912) (Fig. 3713) and Dr. A. MacKenzie Forbes (*British Medical Journ.*, Aug. 30, 1913). Both observers have advocated a new principle in the application of these forcibly applied jackets, and which has resulted in a marked gain in the possible correction of this class of cases. They have shown that the articular processes of the vertebræ are unlocked only in the flexed position and it is in this posture only that the corrective force is effectual, while in the method of extension the spine is in the most resistive position for correction. By this new method the patient is made to lie on a slack, narrow hammock, with the legs suspended in the air, and as much flexion of the trunk as possible is obtained. While in this position the corrective lateral or rotation force is applied. Abbott aiming more at the lateralization force, obtains this by means of straps, for which a specially constructed frame is used. Forbes, aiming at the rotation force, obtains the correction by the forcible rotation of the shoulders and upper part of the trunk. The process in either case is complicated, requiring care and experience in the application of the jackets and for full description the reader is referred to the original articles of the authors. Elliott G. Brackett.

Lathyrismus.—Lathyrism is a food poisoning characterized by spastic paralplegia due to ingestion of bread made of the seeds of different species of vetch, lathyrus, and occurring now chiefly in India.

The disease has long been known and the present theory as to its cause has been the accepted one for many years. Hippocrates mentions that people who feed on pulse get weakness in the legs. The Duke of Würtemberg, 1671, issued an edict against eating bread made from vetch seeds because those who did so suffered from a peculiar stiffness in the legs. Fozetti, 1784, describes an epidemic of this disease occurring in Tuscany where during a famine the people were obliged to eat the seeds of *Lathyrus sativa* Linné. It was very prevalent in India during a three years' famine in 1829–31 during which time the inhabitants were obliged to eat vetch seeds. It still exists in India and has been known in Algiers, Italy, and France.

Etiology.—Whether ingestion of vetch seed is the cause of this disease seems open to question, and is questioned by some who believe the symptoms are not due to lathyrus at all but to the corn-cockle (*Agrostenna githago*) or to the darnel (*Lolium temulentum*). Others believe that vetch seeds produce it only when they have undergone certain kinds of decomposition or certain parasitic growth has taken place in them. The species of lathyrus which have been charged with responsibility according to Castellani and Chalmers, 1913, are *L. sativus*, *L. cicera*, *L.*

clymenum, *L. tuberosus*, and *L. aphaca*. Toxic substances have been obtained by Teilleux (for rabbits) and Bourlier (for birds and frogs). Asher obtained a volatile alkaloid which, however, was not tried out for its toxicity. Horses and pigs are said to be susceptible while bullocks and buffaloes are not. In this respect it resembles another food substance, cotton seed, or cotton seed meal which kills pigs after about four weeks' feeding, while it is one of the best feeds for cattle and perhaps for horses. The idea that the vetch seed may become poisonous as a result of decomposition suggests the instance of another legume, the common field pea. When the vines and peas are cut and thoroughly dried for hay they make splendid safe feed for horses, but if the hay has been improperly cured and mouldy it is most destructive to horses which have very similar symptoms to those described for vetch poisoning in horses.

It is to be noted that the disease occurs only during famine and in conditions of extreme poverty when not only may people be obliged to eat vetch seed but their diet may be very poorly balanced. An exclusive carbohydrate diet has lately been found to produce in experiment animals a neuritis suggesting the symptoms of lathyrismus. In this instance the disease is due to lack of certain substances (vitamines) which are present in infinitesmal quantity in the pericarp of certain grains, rice, oats, wheat, etc., and it may be brought about by eating any one of a number of common foods which are deficient in these substances.

At any rate lathyrismus is caused by famine or extreme poverty, even if it is specifically produced by vetch seed poisoning, because people will not eat them except under such conditions. The pathology is not known, so far as the present writer has been able to learn.

Symptoms.—The symptoms come on insidiously. There is pain in the back and weakness in the legs increasing until symptoms of spastic paralysis appear. The feet are dragged as the patient walks giving rise to a characteristic gait. The arms are not generally affected. The joints of the leg seem very weak, there is rapid muscular wasting and walking becomes impossible. There is no ataxy. There is increased reflex, ankle clonus and decrease in the electrical excitability of the muscles affected. Incontinence and girdle sensation are early symptoms.

The absence of gangrene helps to differentiate lathyrismus from ergotism. It can be differentiated from different forms of beriberi by the absence of dropsy but it is doubtful whether our present knowledge enables us to diagnose many of the cases with certainty. The border line cannot be drawn. The disease improves slowly under good food and hygienic treatment, but contractures, deformity and impaired function occur in cases of long duration. Death seldom is produced directly. There is no medicinal treatment indicated. Bromides have been employed for relief of pain in the back. C. C. Bass.

Laughter is one of the most difficult subjects for scientific consideration, and even for plausible theorizing. This is due largely to the number and variety of the phenomena involved; to the radical distinction between the various types of physical laughter, and the phenomena which appear ludicrous to various human beings. Our subject necessarily passes into wit, humor, drollery, etc. But laughter is not necessarily connected with the ludicrous, nor with that exalted state of mind which finds pleasure in the mere act of frequent laughter. It occurs frequently in the absence of such causes, in the laughter caused by tickling, in the culmination of prolonged weeping in laughter, in the spasmodic, incoercible laughter of psychogenic origin. Laughter has a pathology, not only in the functional states induced but in various accidents due to the momentary helplessness of the subject, and in such connection will be mentioned elsewhere.

Laughter in its typical form is a motor manifestation which consists of a contortion of the features and forcible expiratory efforts of a quick, rhythmic character, causing a shaking of the head and trunk. If prolonged, this interruption of respiration may cause redness and slight cyanosis of the face, generalized flexion movements of the limbs and trunk, and in extreme cases complete helplessness and falls. The sphincters sometimes relax. Paroxysms of coughing which often appear are due no doubt to aspiration of the secretions, and objects in the mouth are frequently swallowed with fatal results. It is commonly claimed that man alone laughs, beginning at the earliest during the fifth month of life.

From one viewpoint laughter is one of a number of analogous manifestations in which the respiratory apparatus is involved, the others being sobbing (an inspiratory disturbance); coughing (under certain conditions); hiccough, etc. Only in typical laughter do we hear the "ha ha" sound, which is readily counterfeited in forced or feigned laughter. Shouting and screaming usually occur in crowds, and like all laughter, show the suggestive element. A subject of no mean interest is repressed laughter. The facial contortions can be suppressed by the will, and the familiar act of stuffing a handkerchief in the mouth makes laughter inaudible. The shaking of the body and red face are often disguised by simulating a coughing spell.

In regard to "laughter equivalents" we may enumerate the smile, and the grin and smirk on the one hand, in which only the facial muscles are involved; and the phenomena known as snickering, giggling, tittering, chuckling, etc. In all of the latter group the respiratory muscles are involved to a slight extent. A chuckle is a true laugh, having the rhythm of the latter, but subdued in character. All the other terms are applied loosely, but the acts they characterize are all marked by very rapid and superficial interruptions of expiration. They often express a silly mental state, and occur especially in women and children; often in situations where all laughter should be repressed. In one form of tittering the tongue touches the upper teeth, in a special attempt at repression. In the first-named group, the smile alone demands special attention. Grin is a generic word, meaning only showing all the front teeth. In connection with laughter it means only a broad smile. The smirk and simper are chiefly feigned smiles but may become habitual, as a type of facial expression often indicating silliness. That a person is sometimes known in the vernacular as a "smiler," shows that such expressions are useful in identification. An habitual smile is often indicative of a happy disposition.

The smile and laugh seem to have been without distinction in semi-barbarous people and even after the development of civilization a smile was regarded as a diminutive laugh, as shown in most languages still in use. In English, *laugh* of Germanic origin seems to have meant any expression of mirth, while *smile* of Scandinavian derivation referred solely to the facial expression. At present it is conceded that smiling while it may appear to be the onset of laughter, is in reality an independent phenomenon. The smile indicative of amusement or pleasure consists simply of the action of certain facial muscles (risorii, etc.) which raises slightly the corners of the mouth; in a higher degree we see the exposure of the upper teeth, which may extend to a grin; finally we note the partial closure of the eyes which appear unusually bright. The twinkle of the eye is under certain circumstances the sole indication of a feeling of mirth. The contractions of the orbicularis and corrugatores supercilii, are held responsible for the so-called "laughing eye."

Smiling differs from laughter in that it is not paroxysmal, occurs in animals and very young infants, does not necessarily involve the opening of the mouth, is easily assumed and repressed, and in polite circles becomes the full equivalent of laughter, the latter being made an attribute of the uncultivated mortal. Well known is the "meaning smile" of certain women who can exchange thoughts with their sex by this resource. One common use of a smile is for purposes of simulation and dissimulation.

The facial contortions of paroxysmal laughter naturally closely resemble a smile, but a paroxysm is laughter from the outset. The mouth opens widely, sounds of various sorts issue therefrom, the face reddens, and the eye closure is often associated with lacrymation. The head, thrown backward, shakes with the trunk.

We can only conclude in this connection that certain mental states make use of certain centrifugal paths to express themselves by a laugh, a smile, or possibly by associations of dissimilar processes.

A question of the present day refers to the utility of laughter. That it is the result of some craving on the part of the body seems unlikely, and the assertion that any increase of nutrition results from daily laughter, is no longer a serious claim, for fat is no longer looked on as an asset. Women and children who are constantly seeking gatherings in which almost continuous laughter is an accompaniment suggest that the act is a simple amusement or diversion—in other words, a source of pleasure. The male secures the same result by attending comical or farcical stage productions and by practical joking. Hearty laughter for several hours relieves the monotony of existence and drudgery.

Sudden involuntary laughter results from a host of surprising and incongruous happenings, but this subject is so connected with studies of the ludicrous, of wit and humor, etc., that it cannot be comprised in this article. The treatises of Sully, Bergson, and Sidis should be consulted for this aspect of laughter.

Finally, laughter can be studied in brief compass by watching the action of cannabis indica in dosage somewhat beyond the normal. The subject, possibly grave and dignified by nature, acquires a mental state in which, with consciousness but slightly clouded if at all, he is excited to merriment by objects which possess no possible element of the ludicrous. The simplest, most common household articles seem able in defiance of association to provoke spasms of laughter. This sense of the ludicrous may last for several hours. As a rule there is no amnesia. EDWARD PREBLE.

Laurus.—LAUREL, *Royal Bay.* The true Laurel of Europe, *Laurus nobilis* L. (fam. *Lauraceæ*), is a handsome, fragrant-leaved evergreen shrub or small tree, from two to six meters in height, with numerous slender, smooth, green, very leafy branches, and dark green, shining, leathery, oblong lanceolate or lanceolate, entire, but often wavy or slightly revolute-margined leaves, and producing an ovoid berry, with soft flesh and a large, fleshy seed.

This laurel is a native of Asia Minor and Syria. It has long been grown in and is probably a native also of Greece and the islands of the Eastern Mediterranean. Further, it has been cultivated in Italy, at least as long ago as the days of classic Rome, and in the southern part of Europe generally, in England for several hundred years, and recently in Mexico and the West Indies. It is very common in this country as an ornamental pot-plant. It is supposed to be the plant dedicated by the ancient Greeks to Apollo, and regarded by them as an emblem of purification, peace, victory, and good luck in general. It is the laurel of sculpture, painting, and literature. The leaves are described under the title "*Bay.*" The fruits are about one centimeter long (two-fifth inch), and when dried are dull brownish black, slightly withered, with a brittle papery exterior and a brown, smooth kernel, splitting easily into two large cotyledons. Odor peculiar, strong, spicy; taste balsamic and bitter.

The fruits are rich in fragrant and fatty constituents, the latter principally in the embryos. The *essential oil* (0.23 per cent.), a colorless or yellow liquid, gives them their odor. The *fatty oil* is obtained by pressing or boiling; it is a yellowish green, buttery soft-solid, fragrant with some dissolved essential oil; it is soluble in ether, but only partially so in alcohol. Laurel fat is a composite substance, consisting of glycerides of oleic and stearic, as well as palmitic, myristic, lauric, and probably other, acids. The leaves, which are used abroad as a kitchen flavor for soups, etc., contain *essential oil, tannin,* a bitter substance, etc.

ACTION AND USE.—The leaves and essential oil have no peculiar action to distinguish them from other fragrant substances. The impure fat of the seeds is moderately stimulant to the skin, and is used as an ointment in rheumatism, paralysis, etc., internally as an aromatic. It is a medicine of great antiquity, but at present it is nearly obsolete so far as the practice of physicians goes. The fruit is but little used, but the leaves are largely imported into the United States. Certain brands of "stick liquorice" are packed in Bay leaves.

Essential Oil of Laurel is an article of commerce and, except for refined distinctions as to odor, etc., is the same from both fruit and leaves. The latter has a specific gravity of about 0.924, the former 0.925. The principal constituents are pinene and cinene.

H. H. RUSBY.

Lavage, Gastric.—Gastric lavage or washing of the stomach is a procedure introduced first by Kussmaul (stomach pump), and later on by Leube and Ewald. The stomach pump of Kussmaul (Fig. 3714) consists of a big syringe with a semi-flexible tube attached. Kussmaul originally applied it in cases of dilatation of the stomach, in order to empty this organ of its contents. Later Leube used this procedure for diagnostic purposes. Instead of the pump Leube employed a glass funnel (Fig. 3715). He also lengthened the tube in such a manner that by raising and

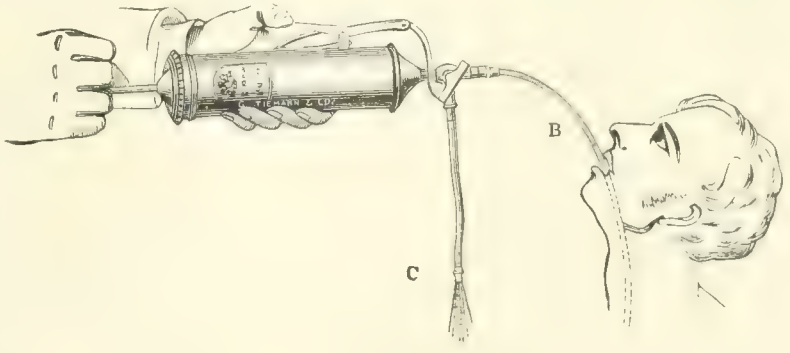


FIG. 3714.—Kussmaul Stomach Pump.

lowering the funnel, water or fluids could be made to run into and out of the stomach (principle of siphonage). Ewald introduced the employment of very flexible rubber tubes which are in common usage at the present time.

It may be well to give first a description of the method of washing the stomach and later to specify

its indications. The apparatus for gastric lavage as generally employed nowadays consists of a soft rubber stomach tube, a connecting glass piece, another plain soft rubber tube of about four or five feet in length, and a glass funnel. The patient sits in a chair or if in bed sits up propped by a pillow. His head should be slightly bent forward assuming a position similar to that of a person sitting at the table when partaking of a meal. A bib is tied around his neck and an empty bucket placed near him either on the bed or by the chair. A pitcher of water (blood temperature) is placed within

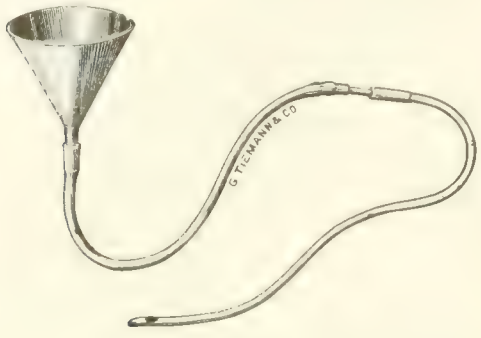


Fig. 3715.—Funnel Arrangement for Gastric Lavage.

reach. Now the stomach tube is dipped in warm water and introduced into the mouth and pharynx of the patient, who then is told to swallow. During the act of swallowing the tube is quickly pushed by the physician into the esophagus and from there into the stomach. (The patient is not required to swallow at any time excepting once in the beginning.) As soon as the stomach tube has reached the stomach (the length being about twenty-one or twenty-two inches from the lips) the tube is connected with the funnel arrangement. The funnel is now held low corresponding to the level of the stomach. The water is poured into the funnel and the latter is then raised to about the level of the patient's head when the water begins to flow into the stomach. As soon as the funnel

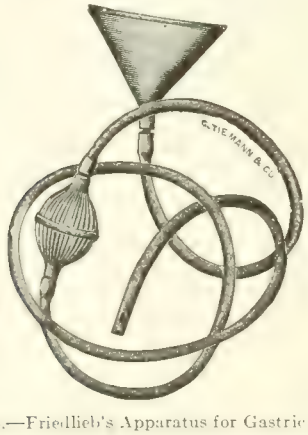


Fig. 3716.—Friedlieb's Apparatus for Gastric Lavage.

is almost emptied another portion of water is filled in. When a pint or a quart of water has been poured into the stomach according to the requirements of the case, the funnel is quickly lowered way down in order to have the water return. As soon as all the fluid has been removed, the funnel is again filled with water and the whole procedure repeated as heretofore.

If the stomach is not entirely empty and the water comes back mixed with food, then it is best to have the patient shake the upper part of his body from side to side, while the water runs into the stomach, in order to have a thorough mixture of the solid particles with the liquid. As a rule the stomach should not be overfilled. As soon as the patient experiences a slight sensation of fullness the inflow must be stopped and the water returned.

Friedlieb's Apparatus.—Another very suitable arrangement for washing out the stomach, especially if the patient has to perform the procedure himself, is an apparatus that has been in use in this country for many years, and is similar to the one described by Friedlieb. It consists of a long piece of soft rubber tubing about two yards in length, the middle of which is expanded into a bulb. The stomach end of the tube is provided with two big openings, while the other is shaped into a funnel (Fig. 3716).

In the withdrawal of the gastric contents with this apparatus the tube should be closed with two fingers at a point situated between the bulb and the lips of the

Fig. 3717.—Leube-Rosenthal Apparatus for Gastric Lavage.

patient. If the bulb is now compressed, and the two fingers applied to its distal side then on relaxing the pressure on the bulb it will become filled with stomach contents. By again closing the upper end of the tube and compressing the bulb, the contents will flow out from the apparatus. In this way the contents of the stomach can be removed. The washing of the organ is now executed in the usual way by filling the funnel end with water raising the same and lowering again. The bulb then need not be compressed if the water flows out easily. If the stream of water stops flowing before the entire quantity has left the stomach then suction by means of the bulb must be performed as above described. Instead of using the fingers in order to compress the tube, two clamps, one on each side of the bulb, may serve the same purpose.

Leube-Rosenthal Apparatus.—This consists of a large

glass irrigator of about two or three quarts capacity (Fig. 3717). Leading from the irrigator a large piece of soft rubber tubing is connected by means of a Y-shaped glass tube—first with a stomach tube, secondly, with another quite long piece of soft rubber tubing. Both arms of tubing, the one running from the irrigator, the other into a waste vessel, are provided with clamps. By opening the clamp on the irrigator tubing, the water runs into the stomach. By closing the same and opening the one on the tube running to the waste vessel, the water is withdrawn from the stomach. The amount of water which is used for each single filling of the stomach may vary from 440 c.c. to one liter.

The advantages of this apparatus are quite evident: (1) the ease with which the whole procedure can be executed; (2) the water introduced into the stomach is always clear, as the waste water passes through a separate tube; while in the use of the funnel arrangement after the first filling, the funnel and the tubing become soiled during the withdrawal of the contents, and in consequence of this during the second filling, much of the mucus which has remained in the apparatus, returns into the stomach.

This apparatus is the best for office work.

Indications.—Aside from diagnostic purposes lavage must be performed—(1) when there is stagnation of food in the stomach; (2) whenever large quantities of mucus are present in the organ; (3) after poisoning by the ingestion of alkaloids (morphine, atropine, cocaine, etc.) into the stomach; (4) in postoperative ileus.

Contraindications.—These comprise all conditions in which introduction of the tube is not permissible, as for instance, hemorrhages, ulcer of the stomach, aneurysm, poisoning by strong acids or caustics; great general debility. Max Einhorn.

Lavandula.—Lavender: *Lavandula angustifolia* (L.) Miller (fam. *Labiatæ*). A perennial, partly shrubby plant, with short, crooked, branching stems, and numerous slender, upright, simple branches, from one-third to more than one meter in length. Leaves opposite, linear with entire, slightly revolute margins. Flowers in small opposite cymes, closely aggregated into spike-like clusters at the ends of the slender erect branches. All the green parts, calyx, branches, and leaves, are covered with a tomentum of stellate hairs and stalked glands. Calyx tubular-ovoid, with only one lobe (the upper) developed. Corolla tubular, curved, with spreading two-lipped border, lobes of both lips rounded, those of the upper longer and straighter than those of the lower, color pale violet; stamens four, inserted in the corolla tube, ovary four-celled and four-seeded. Lavender is a native of the southern part of Europe and the northern border of Africa, growing in elevated and dry places. It has also been cultivated for centuries, and the herbage, flowers, and oil are all in the market.

The flowers, dried, are about five millimeters long (one-fifth inch), of a general blue-gray color, with very hairy calyx. The retention of the bright blue color of the flowers is an indication of careful drying, freshness, and fine quality. The fragrance is delightful, the taste bitterish, aromatic, somewhat camphoraceous.

Composition.—Lavender flowers contain about one or one and a quarter per cent. of *essential oil*, which they retain, if properly kept, for years; the stems also contain a similar but less agreeable oil. With this oil there is a little tannin and resin.

Action and Uses.—The action of lavender is purely that of an aromatic stimulant and carminative, like its relatives in the family. Its odor is highly esteemed by almost every one. It is not strange, therefore, that aside from the oil, both the plant and the flowers should have an extensive use, especially in domestic practice. Both have been official in our own and other pharmacopœias, but professional use is now almost entirely restricted to the oil, which is described below. The dose of lavender is one to four grains (gr. xv.–lx.) corresponding to about one minim of the oil, though the latter is given in larger doses.

Lavender, Oil of. Oleum Lavandulæ Florum (U. S. P.). Both the oil of the plant and that of the flowers are commercial, and both have been official, though only that here considered is so at present. They are very similar, that of the flowers being only a little finer. The official article is a colorless or yellowish liquid, having the fragrant odor of lavender flowers and a pungent and bitterish taste. Specific gravity 0.88 to 0.892 at 25° C. (77° F.). It is soluble in three parts of seventy per cent. alcohol. When shaken with water in a narrow graduated cylinder, its volume should not be diminished (*absence of alcohol*).

A number of inferior oils, from other species of lavender, chiefly spike oil, from *L. spica* Cav., are in the market and are all distinguished by their much higher specific gravity, that of spike oil, the highest, ranging from 0.905 to 0.920.

The active portion of oil of lavender is *linaloyl acetate*, which should constitute about one-third of it.

The dose of lavender oil is ♏i. to v., though it is comparatively little used internally. The official spirit has a strength of five per cent. The compound tincture, or compound spirit, contains, with 8 parts of this oil, 2 of oil of rosemary, 20 of cassia, 10 of nutmeg, 5 of cloves, in a thousand, and is colored with red saunders. Henry H. Rusby.

Laverania.—A synonym for the sporozoan genus *Plasmodium*, of which the malarial parasites are examples. See *Malaria* and *Protozoa*. A. S. P.

Laxatives.—See *Cathartics*.

Lazear, Jesse William.—Born in Baltimore, May 2, 1866. He received his bachelor degree from Johns Hopkins University in 1889 and was graduated in medicine from the Medical Department of Columbia University (College of Physicians and Surgeons) in 1892. After a term of service as interne at Bellevue Hospital, New York, he spent some time in study in Europe. Upon his return to this country he was appointed bacteriologist to the Johns Hopkins Hospital and assistant in clinical microscopy in Johns Hopkins University. He volunteered as a member of the Medical Corps, U. S. A., in the Spanish War, and after its close, in 1900, was appointed on the Yellow Fever Commission under Major Reed in Havana. In the course of the investigation he allowed an infected mosquito to bite his hand, and this was followed by an attack of yellow fever from which he died within a few days on September 26, 1900. Lazear was a true martyr to science, even as was Carroll, his colleague on the commission, for when he allowed the insect to sting him the members of the commission were already nearly convinced that the disease was transmitted in this way, although further proof was needed to establish the theory firmly. A memorial tablet has been erected to his memory at Johns Hopkins Hospital, Baltimore. T. L. S.

Lead.—See *Plumbum*.

Leaming, James Rosebrugh.—Born at Groveland, N. Y., February 20, 1820, he was graduated in medicine from the New York University in 1849. He began practice in New York City in the office of Dr. Cammann, and soon acquired a reputation as a

diagnostician of great acumen especially skilled in physical diagnosis. He was also a bold and successful therapeutist. One of his firm convictions was that calomel in large doses was curative of pneumonia, and when he himself suffered a severe attack of that disease he persuaded his medical attendant to give him a thirty-grain dose of calomel—he speedily recovered. Another of his firm beliefs was in the curative virtue of thuja applied locally in malignant ulceration. He died December 5, 1902.

The following are the most important of Dr. Leaming's contributions to medical literature: "Cardiac Murmurs," New York, 1868; "Respiratory Murmurs," New York, 1872; "Plastic Exudation within the Pleura; Dry Pleurisy," Philadelphia, 1873; "Significance of Disturbed Action and Functional Murmurs of the Heart," New York, 1875; Contributions to the "Study of Diseases of the Heart and Lungs," New York and London, 1884 and 1890.

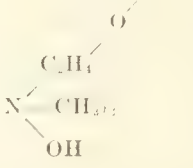
T. L. S.

Lebert, Hermann.—Born in Breslau, Germany, June 9, 1813. (The family name was originally Lewry.) He studied medicine first in Berlin and afterward in Zürich, under Schoenlein, and received his doctor's degree from the latter university in 1834. During the following eighteen months he followed the clinical instruction of Dupuytren and Louis, in Paris, and in 1838 he settled in Bex, Canton de Vaud, Switzerland. From 1842 to 1845 he devoted the greater part of his time to the study of comparative anatomy. During the following eight years he engaged in private practice in Paris, and at the same time did a good deal of scientific work. In 1853 he was made Professor of the Medical Clinic at Zürich; in 1859 he was called to fill the same chair in Breslau; and finally, in 1874, he definitely settled in Bex for the few remaining years of his life. He died August 1, 1878.

Lebert was one of the very first to utilize the microscope extensively in pathologico-anatomical researches, and he was thus enabled to make quite a number of valuable contributions to our knowledge of pathology and clinical medicine. These contributions, which already in 1869 numbered over one hundred publications (large and small), may be divided into three classes: those relating to biology; those belonging more strictly to medical science; and, finally, the majority of his shorter writings—such as reports of cases, papers on experimental pathology, accounts of the climatological conditions of such resorts as Nice, Vevey, Bex, etc. Of the publications of the second group the following are the more important: "Physiologie pathologique," two volumes, Paris, 1845; the splendidly illustrated, "Traité d'anatomie pathologique générale et spéciale," two volumes, Paris, 1852–1864; "Traité pratique des maladies scrofuleuses et tuberculeuses etc." (awarded a prize), Paris, 1849; and "Klinik der Brustkrankheiten," two volumes, Tübingen, 1874.

A. H. B.

Lecithins.—These substances belong to the group of lipoids, or fat-like substances, and the group of lecithins are designated as phosphatides. As their name implies they are compounds containing phosphorus. This element is combined with nitrogen and fatty acid in an ester form. The number of lecithins possible is almost unlimited the different lecithins differing from one another according to the fatty acid radicle or radicles contained in the molecule. A typical lecithin is an ester combination of a nitrogenous base, choline, and a fatty acid glycerophosphoric acid. The lecithins belong to the group of the monophosphatides since they contain only one phosphoric acid radicle. As an example of the typical structure of a lecithin, the following may be given



The amount of phosphorus in lecithins varies from 3.7 to 3.9 per cent. and nitrogen is present to the extent of 1.7 to 1.9 per cent. Upon boiling with alkalies (saponification) lecithin is decomposed with the formation of soaps, choline, and glycerophosphoric acid whereas under the influence of acids lecithins are only slowly decomposed. The lecithins may also be split into their constituents by the action of enzymes, particularly lipase.

Lecithin may be regarded as a primary cell constituent being present in practically all types of cells of both animal and plant origin. Lecithin is soluble in alcohol, especially in warm alcohol, ether, chloroform, carbon disulphide, benzene, etc. From its alcohol-ether solution lecithin may be incompletely precipitated by acetone. Upon putrefaction lecithin yields glycerophosphoric acid and choline, and the latter furnishes methylamine, ammonia, carbon dioxide, and marsh gas. Lecithin combines with acids and bases. With the hydrochloric acid solution a platinum salt may be formed which is quite insoluble in the reagents which are ordinarily solvents for lecithin. Lecithin combines with a protein molecule to form the group of proteins known as lecithoproteins. As an example of lecithoprotein may be mentioned vitelline of the egg.

Frank P. Underhill.

Leeches.—See *Hirudinea*.

von Leeuwenhoek, Anthony.—Born at Delft, Holland, October 24, 1632. His chief distinction seems to have been that he discovered how to grind a lens of short focal distance in such a manner that, for the purposes of the anatomist and the naturalist, it proved a more staisfactory working instrument than were the compound miscroscopes then in use. Having thus acquired the means of ascertaining more correctly the relations of the finer structures of the body, Leeuwenhoek made "many interesting discoveries in the minute anatomy of man, the higher animals, and insects. He confirmed and extended Malpighi's demonstration of the blood capillaries in 1668, and six years later he gave the first accurate description of the red blood-corpuscles, which he found to be circular in man but oval in frogs and fishes. In 1677 he described and illustrated the spermatozoa in dogs and other animals, though in this discovery Stephen Hamm had anticipated him by a few months, and he investigated the structure of the teeth, crystalline lens, muscle, etc." (Encyl. Brit., 11th ed.). His death occurred at Delft August 26, 1723.

A. H. B.

Leg, Anatomy of the.—In anatomy the term leg indicates only that part of the pelvic limb between the knee and the ankle, the portion above the knee being known as the thigh.

In man the shape of this region is characteristic. In most other animals the bellies of the great muscles are above the knee, and the leg is comparatively slender; in man, however, the erect position requires the constant application of muscular force to hold the foot at

right angles to the axis of the limb, and this causes very considerable bellies to be formed below the knee. The prominence of the calf marks the higher races of mankind generally, and Australians and other low savages resemble children and apes in the slender caliber of their legs.

It is not quite correct to compare the leg to an inverted cone, as is often done. In a fully developed man the prominence of the calf is confined mainly to the proximal and posterior part of the limb, and represents the two bellies of the gastrocnemius, the medial

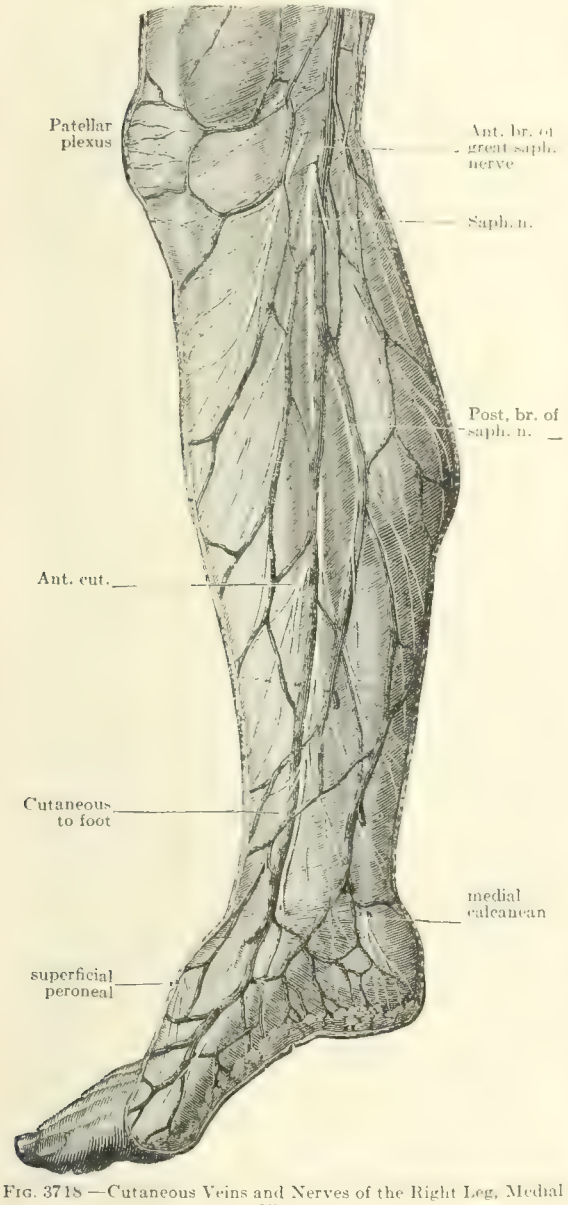


Fig. 3718.—Cutaneous Veins and Nerves of the Right Leg, Medial View.

one being larger and descending somewhat farther than the lateral. This prominence is enormously developed in ballet-dancers, who possess here a dense, hard muscular ball, quite characteristic of the occupation. It may be brought out more fully by rising upon the toes. In women the calf has usually a somewhat different shape, the muscular prominence being masked to a certain extent by fat, and descending somewhat lower than in males. The bones being more slender, the ankle is more finely modelled, and the whole contour of the limb approaches more nearly those lines of grace which please the eye in the "Greek Slave" or in Canova's "Venus." It is this contraction of the leg toward the ankle that makes it necessary to take certain precautions in bandaging, by proceeding from below upward and making the necessary reverses. It is also the reason why the circular operation for amputation is not so easily performed here as above the

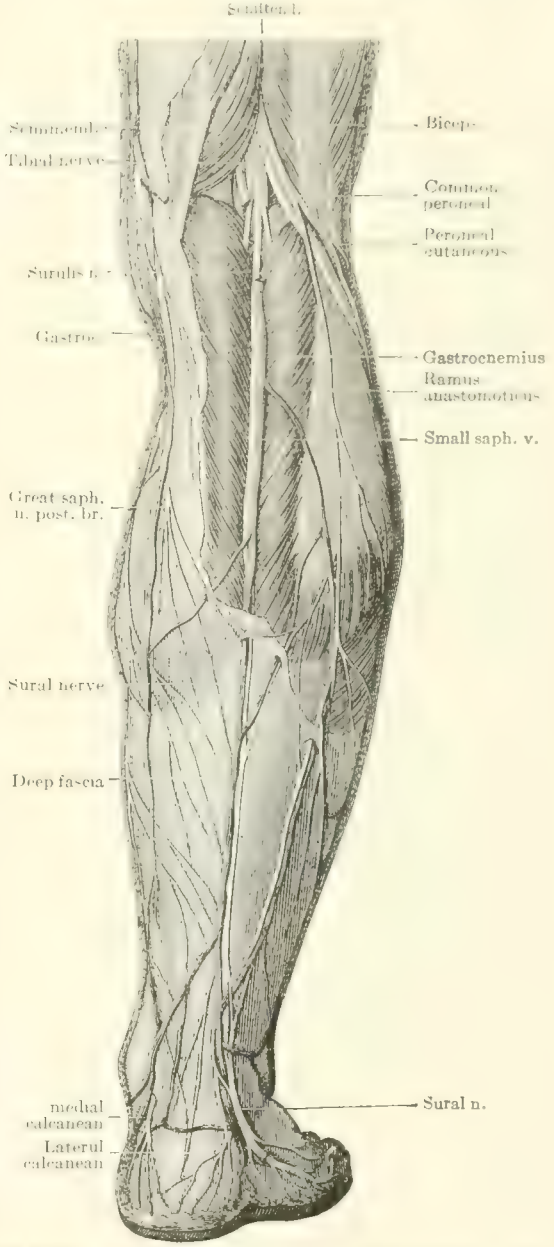


Fig. 3719.—Branches of Right Small and Great Saphenous Veins.

knee, it being difficult sufficiently to retract the "sleeve." The shape of the ankle is, however, far from being cylindrical, the strong, flat tendo calcaneus (Achillis) producing a prominent projection behind, as will be seen on inspecting Figs. 3721 and 3724. Anteriorly, the leg is remarkable for the considerable area throughout which the bone is quite superficial. The

medial surface of the tibia, along its whole length from the tuberosity downward to the end of the malleolus, is but slightly covered, and in case of fracture the ends are very apt to extrude, a compound fracture being more frequent here than in any other part of the body. The anterior edge, popularly termed the shin, may be followed down as far as the lower third, where it begins to be rounded and covered with tendons that pass over the ankle into the foot. The lack of soft parts here to serve as a cushion under the skin occasions liability to certain injuries. A blow from a blunt instrument which would elsewhere produce a contusion will here cause an incised wound. Blows may also produce the same blood tumors that we see occasioned in a similar way upon the skull.

The usual curve of the crest of the tibia may be exaggerated by various causes. One of the earliest signs of rickets is an increase of the bend at the distal part. If children are encouraged to walk too early there is usually an outward bend, causing the child to appear bandy-legged. It is probable, however, that when this is considerable, there is a defect in the nutrition of the bones. Where the potable water shows a marked deficiency of lime salts deformities of this kind are more common. Still, it is not unusual to see the limbs of a bandy-legged child straighten as puberty approaches, and it may be questioned whether a certain degree of this defect is not due to a reversion to the type of tibia found in our "frugivorous ancestors of arboreal habits." Among negro children bandy legs are very common. As this defect occasions an unusual prominence of the shin, and consequent liability to injury, it is probable that there may be some slight ground for the prevalent notion that the shin of the negro is one of his most vulnerable points.

In certain races, especially those that approximate to the prehistoric type, such as the Esquimaux, Patagonians, certain Indians, early Europeans, and the mound-builders, a peculiar form of tibia is found which is decidedly simian in character. The bone is

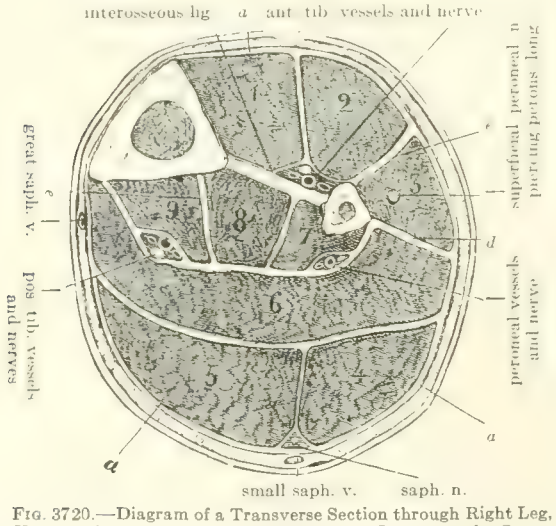


Fig. 3720.—Diagram of a Transverse Section through Right Leg, at Upper Third, to show the Disposition of the Intermuscular Septa. Distal surface of section. *a*, *a*, *a*, Deep fascia or aponeurosis; *d*, *e*, intermuscular septa; 1, tibialis anterior; 2, ext. dig. long.; 3, peroneus longus; 4, lateral head of gastroc.; 5, medial head of gastroc.; 6, soleus. 7 flex. hall. long.; 8, tibialis posterior; 9, flex. dig. long.

markedly flattened from side to side, and presents a saber-like edge on the crest. This is known as the platycnemic tibia. Wyman found upon examination of a considerable number of skeletons of the mound-builders that about sixty per cent. of their tibiæ were platycnemic. It seems quite probable that in such legs the tibialis anterior muscle is larger and more deeply embedded between the bones than is the case in the usual type, adapting the foot to strong inversion of the sole, as is the case in apes, and thus making climbing easy.

The fibula, although not so superficial as the tibia, may be felt for a great portion of its course, especially

Fig. 3721.—Transverse Section of Left Leg, just above the Bases of the Malleoli. Distal surface of section. 1, Tendon of tibialis anterior; 2, ext. hall. longus; 3, ext. dig. longus; 4, flex. hall. long.; 5, peroneus brevis; 6, peroneus long.; 7, tibialis posterior; 8, flex. dig. long.; 9, tendo calcaneus; 10, plantaris; 11, fatty tissue; 12, sheath of posterior tibial vessels and nerves; 13, great saphenous vein and nerve; 14, small saphenous vein and nerve; 15, anterior tibial vessels and nerves.

below, where fracture is most common. The head and the lateral malleolus, with the triangular facet above it, are subcutaneous. The close contiguity of the skin to the periosteum and bone makes it very easy for pathological processes to be continued from one to the other. It often occurs, therefore, that ulcers of the leg are followed by periostitis and necrosis of the bone.

The skin and subcutaneous tissues are not so freely supplied with arterial vessels as are the corresponding portions of the upper extremity. The superficial veins are, on the contrary, very numerous, as may be seen on an inspection of Figs. 3718 and 3719. Being far removed from the heart, acting against gravity, outside the muscles and therefore without the assistance of muscular contraction, the circulation through them is unusually sluggish.

These peculiarities cause this region to be particularly liable to congestive disturbances and to defective nutrition. Eczema is common here; it is a favorite locality for the spots of purpura, and patches of brownish discoloration appear from the staining of the skin with the coloring matter of the blood, especially in old persons who heat the legs much before the fire. This the older physicians called *ephelis ab igne*, indicating its relation to freckles, or *ephelis a sole*. Ulcers are very common here; a small abrasion, which would elsewhere heal without trouble, here remaining indefinitely, and being very difficult to cure without placing the patient for some time in a recumbent position. The most common situation for ulcers is naturally where the bones are subcutaneous, and the leg most exposed to violence. Syphilitic ulceration is also common, especially in front of the knee.

The principal venous trunks are two. The great saphenous vein (Fig. 3721) arises on the inner side of the foot from the medial extremity of the dorsal venous arch, courses upward in front of the medial malleolus, then behind the medial border of the tibia,

and passes into the thigh behind the medial condyle of the femur, finally discharging into the femoral vein through the fossa ovalis of the fascia lata. The small saphenous vein (Fig. 3721) arises from the lateral end of the dorsal venous arch of the foot, passes behind the lateral malleolus, upward along the tendo calcaneus over the gastrocnemius, and penetrates the deep fascia to empty into the popliteal vein. Both of these veins communicate frequently with the deeper veins by short branches through the fascia, and both are accompanied by cutaneous nerves.

For the reasons above mentioned these veins are very liable to become varicose, especially with those who stand much in one position, like washerwomen, and these varicosities usually occur at those points where a communication exists between the superficial and deep systems. The enlargement frequently occasions considerable pain because of the pressure upon the accompanying nerves. Varicosities are also likely to occur in those whose occupations require them to use powerfully the muscles of the leg while the thoracic and abdominal muscles are comparatively fixed, as, for instance, in pushing a heavily loaded wheelbarrow uphill. In doing this the vein is constantly acted upon by the contraction of the leg muscles, which force the blood from the deep veins into the more superficial ones, and is also affected by the weight of the superincumbent column of blood and the compression exercised upon it by the muscular action of the diaphragm and the abdominal muscles. The wearing of tight garters, or any other obstruction to the circulation, such as a gravid uterus or an abdominal tumor pressing on the main vascular trunks, is liable to occasion varices, anasarca, or some other symptom of congested circulation. It is found that the left leg is more commonly affected in this way than the right. This may be partly accounted for by the presence of the pelvic flexure of the colon on the left side, which, containing periodically an accumulation of feces, presses on the iliac veins. Probably atony of the walls of the colon, with a dilatation and partial impaction of the pelvic flexure, is less rare than is commonly supposed. It is said that cold feet have been cured by thoroughly washing out the colon, and thus modifying the circulation of the limb.

But another cause for the greater frequency of affections of this kind in the left leg is the peculiar arrangement of the iliac veins. Since the vena cava is on the left side of the spine, the left common iliac has to cross to the opposite side, and in doing so dips under the right common iliac artery, which is crossing in a similar way from the aorta to the right side. A little lower down, the iliac vein passes under the left common iliac artery. In both these cases the artery crosses nearly at right angles to the direction of the vein, and at every pulsation occasions a certain amount of obstruction to the free flow of blood through the latter. On the right side the arteries cross the veins obliquely, so that there is much less obstruction.

Varices are not confined to the superficial veins. Verneuil thinks that they frequently occur in the venous plexus which exists between the superficial and deep muscles of the calf, and that this may explain the pain which occurs without obvious cause in those whose occupation requires them to stand a great deal. It is interesting to note that we may trace the ultimate cause of varices to the erect posture. Man is the only animal in which the weight of the whole column of blood contained in the vena cava presses directly upon the veins of the lower limbs. The cava has no valves, and, recalling the action of the hydraulic press, we see at once what a powerful effect the weight of the column of blood must have. This defect in the structure of the vascular system is explained when we remember that in other animals the vena cava is, in the ordinary posture, nearly horizontal, and the blood which it contains exerts no pressure upon the veins of the leg. The leg itself is amply provided with valves. The absence of valves at just the point where they would be of most use is really one of the many proofs which anatomy gives that man has assumed the erect posture within so recent a period that the body is not yet perfectly adapted for it.

The fascia covering the leg is arranged as in the other limbs. A single dense layer ensheaths the whole, blending intimately with the periosteum wherever it touches the bone, and with the ligaments both above and below. Its thickness prevents abscesses from readily appearing on the surface, and pus usually burrows along the intermuscular septa.

The sartorius at its insertion sends a strong aponeurotic expansion to it, so that any action of the muscle makes the fascia tense. The superficial muscles of the leg have all a considerable origin from the fascia, and this greatly increases their efficiency. They also arise from the septa which the fascia sends down between the muscles. Of these there is one on the lateral side, passing medially to the posterior border of the tibia, and one passing between the tibia and fibula, usually called the interosseous ligament (Fig. 3720). These two separate the muscles in front and laterally from the posterior muscles, thus dividing the leg into two separate compartments which are practically independent of each other as any effusion in one never passes into the other. The muscles in the anterior compartment are so compressed by the dense tissues surrounding them that they usually bulge out through an incised wound, and when it is necessary to make in it a longitudinal incision, as, for instance, when the anterior tibial artery is tied, it is advisable to relieve the sharp tension of the edge of the fascia by a cross cut.

The anterior compartment is subdivided by a layer of fascia extending from the external sheath to the anterior border of the fibula, separating off the peroneal muscles from the remainder. The latter again are separated by a fibrous partition, that passes between the anterior tibial and the extensor digitorum longus. This well-marked fibrous septum may be used as a guide in tying the anterior tibial artery. In the lower part of the leg the extensor of the great toe and the peroneus tertius lie directly outside the tibialis anterior. The order in which the tendons pass down over the instep is shown in the article on the *Foot*.

The anterior tibial artery (Fig. 3722) is the chief object of surgical importance in the anterior compartment. It is the smaller of the two divisions of the popliteal, and attains the front of the leg by passing between the two heads of the tibialis posterior muscle and above the interosseous ligament, which is wanting in the proximal part of the tibiofibular interspace. It is here very firmly united with the denser fibrous tissues, and it is very difficult to secure it when wounded. Hemorrhage is usually profuse, and it is often necessary to tie the femoral artery to control it. A line drawn from the medial side of the head of the fibula to midway between the malleoli indicates the general direction of the vessel. The lower point should be estimated by standing directly in front of the foot with a finger on each malleolus. As the artery lies in the first muscular interspace that occurs on passing laterally from the tibial crest, there may be a slight groove brought out directly over the course of the artery when the muscles are caused to contract by strongly bending the foot upward. The proximal portion of the vessel lies deeply against the tibia and the interosseous membrane, and between the tibialis antior and the extensor digitorum longus. It is here very difficult to reach and is tied only when wounded, in which case the usual rule is followed of enlarging the wound and securing the bleeding ends. Lower down, as the muscles become tendinous, the artery is more accessible and easily secured. It then lies between the tibialis anterior and the extensor hallucis longus, the latter tendon covering it just as it passes under the cruciate crural ligament to become the

dorsalis pedis. The artery is accompanied by the deep peroneal nerve which reaches it by passing around the head of the fibula (Fig. 3723), where it is somewhat liable to injury. The nerve is, therefore, at first lateral to the vessel, but afterward lies in front and occasionally crosses to the medial side. Venæ comites accompany the artery, and by their frequent anastomoses greatly increase the difficulty of securing it. It is not unusual for the artery to be wounded by splinters of bone when the tibia is fractured; and the nerve may also be injured in the same manner, causing great pain, which may appear to the patient to be in the foot or ankle. Section of the nerve is not a serious

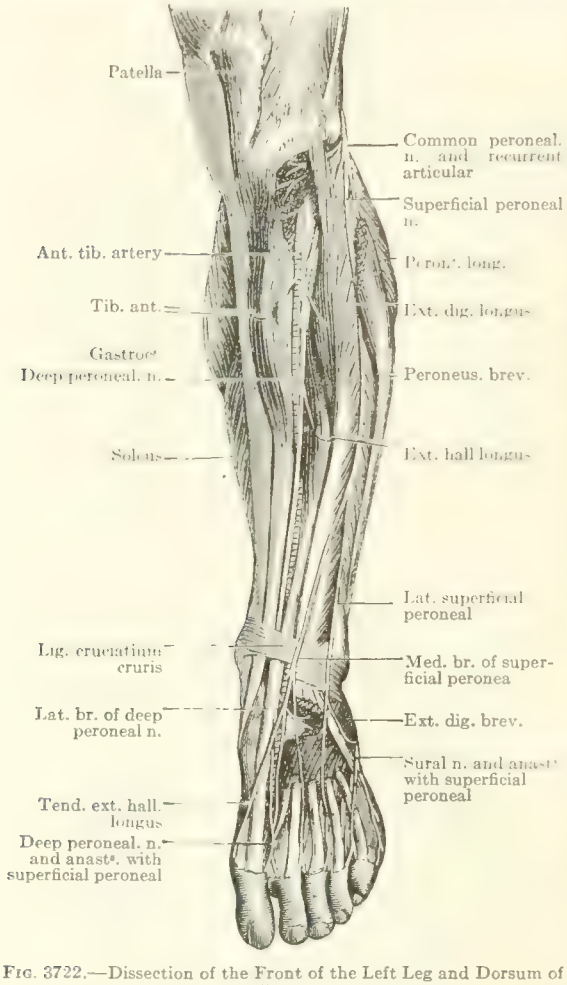


Fig. 3722.—Dissection of the Front of the Left Leg and Dorsum of Foot.

matter, as it does not alter notably the functions of the member.

In the lateral or peroneal compartment there are but two muscles, the peroneus longus and peroneus brevis (Fig. 3723). These are long and slender, attached strongly to the fibula and to the deep fascia above, and tapering below into rounded tendons, which pass behind the lateral malleolus. They are supplied by the common peroneal nerve which may be injured by a fracture of the fibula, whence may result a considerable impairment of the functions of the foot, as the outward pointing of the toes is mainly accomplished by these muscles. The head of the fibula is sometimes torn off by the sudden muscular traction of the biceps muscle, and the lesion is usually accompanied by a considerable amount of pain which may continue during the entire time that the callus is forming. This is due to the close contiguity of the superficial peroneal nerve.

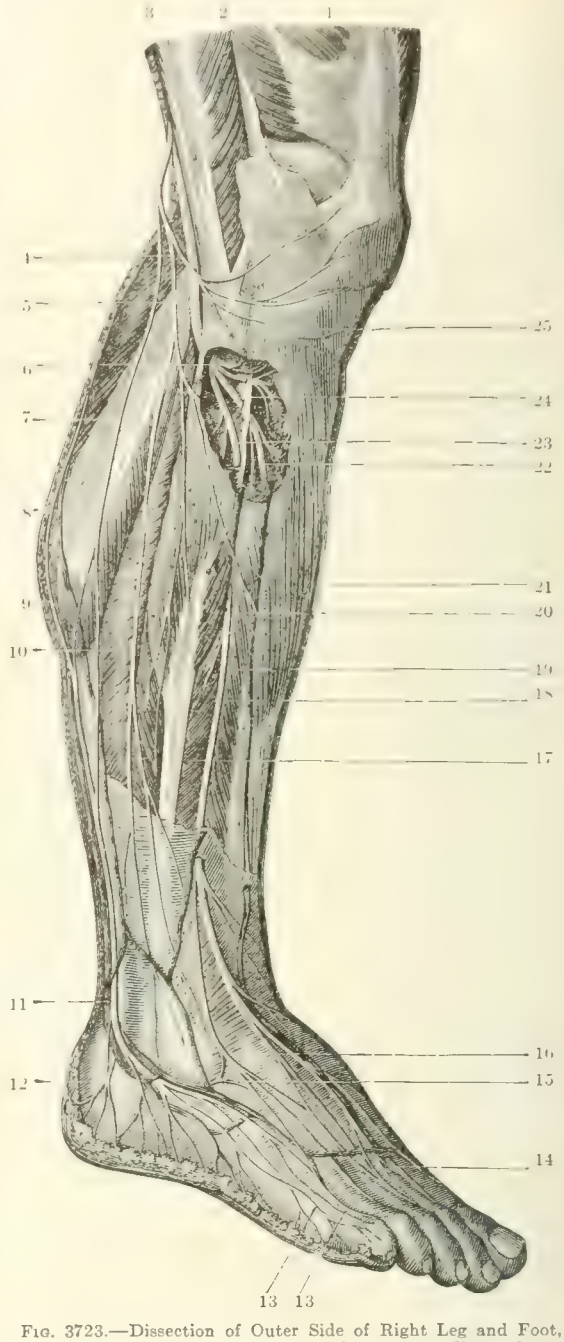


Fig. 3723.—Dissection of Outer Side of Right Leg and Foot, showing Branches of Common Peroneal Nerve. 1, Vastus lateralis; 2, lateral intermuscular septum; 3, biceps; 4, later. cutan. sural nerve; 5, common peroneal nerve; 6, muscular branch; 7, anastomotic; 8, gastrocnemius; 9, medial cutaneous sural; 10, soleus; 11, sural; 12, lateral calcaneal branches; 13, 13, later. cutan. dorsal nerve; 14, digital nerves; 15, anastomotic branch; 16, aponeurosis; 17, peroneus brevis; 18, superficial peroneal nerve; 19, extensor digitorum longus; 20, peroneus longus; 21, tibialis anterior; 22, peroneus profundus nerve; 23, peroneus superficialis nerve; 24, tibialis anterior; 25 head of fibula.

The posterior compartment of the leg is by far the largest of the three. A strong intermuscular septum divides it transversely into two (Fig. 3720), separating

the muscles into superficial and deep groups. The superficial group is attached to the tendo calcaneus and therefore act together as a rule. These form the prominence of the calf before mentioned, and consist of the gastrocnemius superficially, under it the soleus, which consider-

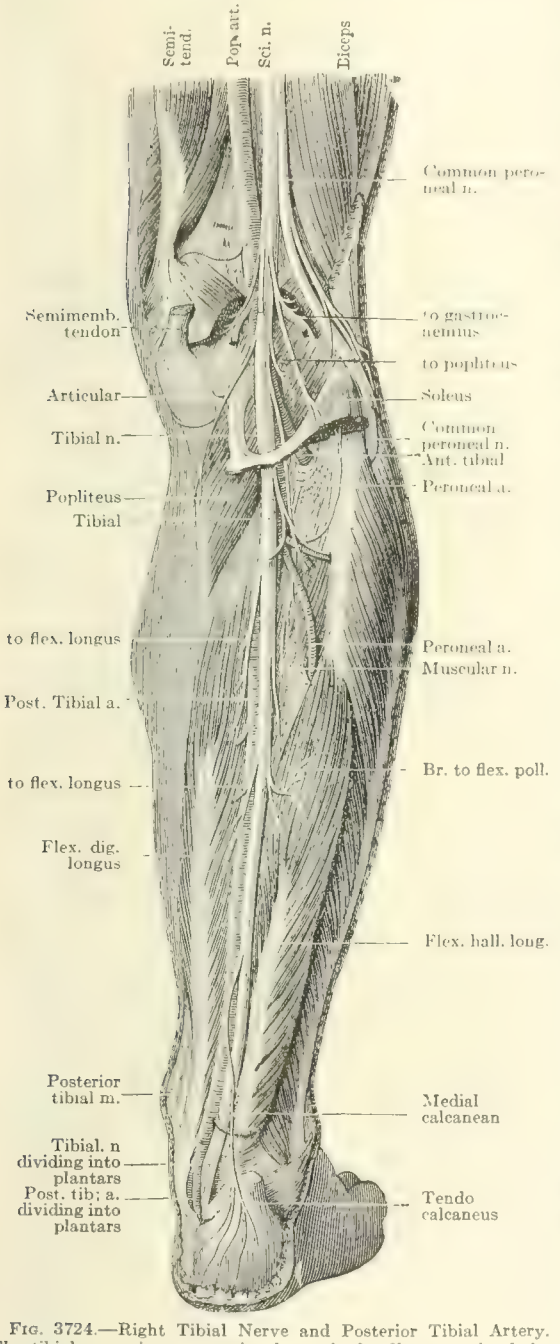


FIG. 3724.—Right Tibial Nerve and Posterior Tibial Artery. The tibial nerve is seen passing beneath the fibrous arch of the soleus.

ably exceeds it in size, and the insignificant plantaris. Many anatomists describe the gastrocnemius as two muscles, and from this conception arises the French name *les jumeaux*. Combined with the soleus the whole muscular complex is known as the triceps suræ. The two heads of the gastrocnemius take origin above the condyles of the femur; it is, therefore, a muscle that controls two joints, and its contraction flexes the knee and at the same time extends the foot. When it is affected by rheumatism it may cause spurious ankylosis of the knee-joint. The coexistence of extension of the foot will enable the observer to distinguish it from true ankylosis. The fibers of either head are arranged in a beautiful penniform manner around a tendon that cannot be completely displayed until the muscle is cut and turned back. Its coadjutor, the soleus, does not pass over the knee-joint, but is attached to the tibia and the fibula, throwing across between the two a fibrous arch of fascia which protects from compression the vessels as they pass under it. The gastrocnemius and the soleus are remarkably subject to cramps. This muscular affection, which appears usually to be an irregular muscular action, independent of the nervous system, may be brought about by slight causes, such as a draught of air blowing on the calves, and vigorous exercise in swimming or running, especially when cold currents are directed on the limb. The greater frequency of the disorder in these muscular masses is probably due to the peculiarities of the blood supply to the leg, to which allusion has been made, and anything that tends to produce a more active circulation through the muscles, such as kneading or rubbing, will relieve the cramp. It is suggested that both in this case and in others in which massage upon the leg is necessary, some care be taken to apply it along the trunks of the veins and in a direction from the periphery toward the heart. Cramps of these muscles are frequent during pregnancy, and in such case may be due to pressure either upon the iliac veins or upon the nerve trunks in the pelvic cavity.

The little plantaris (Fig. 3725) is a vestigial muscle, representing a much larger one found in other animals. Its muscular portion is frequently not more than an inch long. It arises above the lateral condyle of the femur, and terminates in a slender, thread-like tendon, that passes down along the medial border of the tendo calcaneus, and is finally inserted with it into the posterior border of the calcaneum. It is probably of no importance whatever, though the French surgeons have imagined that its tendon may be ruptured by a sudden action, producing the affection known as *coup de fouet*—a sudden stinging pain in the calf. This affection is not rare. In a case within the writer's knowledge it occurred to a lady while dancing. It is more likely that there is a rupture in the large muscular mass of the gastrocnemius and the nerves of supply. It is not clear that the little tendon of the plantaris would cause any pain if it were to rupture, and the lesion has never been demonstrated clinically, so far as the writer is aware.

The tendo calcaneus passes down to be inserted upon the tuberosity of the calcaneum which projects behind the malleoli and constitutes an arm of the lever which lifts the body when rising on the toes. In negroes and others with flat feet this projection is somewhat greater. By this setting back of the tendon two fossæ are formed, one on either side, behind the malleoli (Fig. 3721).

Between the triceps suræ and the deeper layer are the principal vessels and nerves. The posterior tibial artery (Fig. 3724) is the direct continuation of the popliteal, and receives its name on passing under the fibrous arch of the soleus. It almost immediately gives off the anterior tibial and the peroneal arteries, the rule being, according to Holden, that in amputations one inch below the head of the fibula one artery is divided, two inches two arteries, three inches three arteries. It bifurcates into the plantar arteries at a line drawn from the point of the malleolus to the middle of the heel (Wyeth). If we take a point midway on this line, and draw another line upward through the center of the calf, we shall have approximately the course of the artery. In the proximal part of its course it is so deeply buried under muscular masses that it is very difficult to reach. On this ac-

count it is usual in ligating it not to make the incision directly over the artery, but to avoid cutting the gastrocnemius by commencing only two finger-breadths from the medial edge of the tibia, finding the edge of the gastrocnemius, and pushing it aside. The fibers of the soleus are then carefully divided in the direction of the artery. There is usually a deep aponeurotic tendon inclosed within the fibers of the soleus, having muscular fibers inserted on its anterior and posterior surfaces. When this is reached it serves as a warning

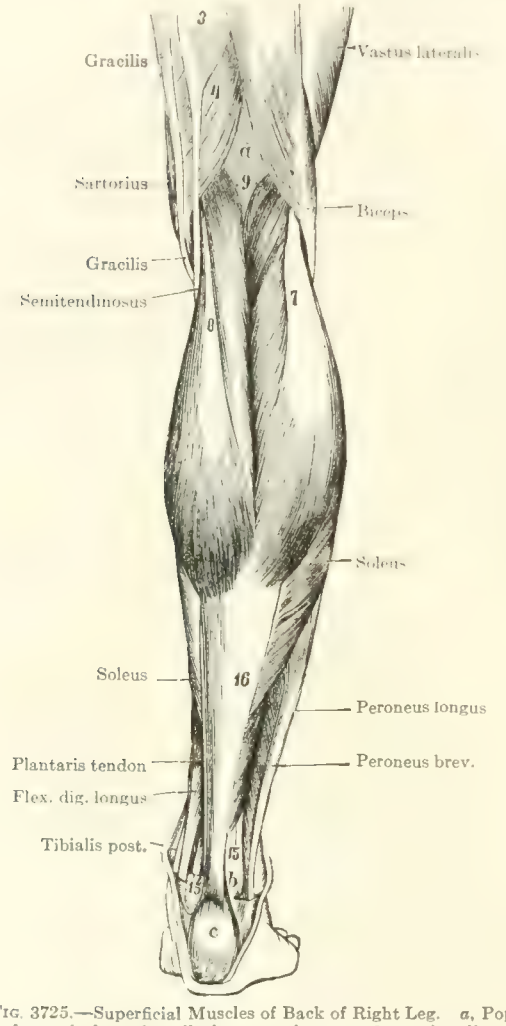


FIG. 3725.—Superficial Muscles of Back of Right Leg. *a*, Popliteal fossa; *b*, lateral malleolus; *c*, calcaneus; 3, semitendinosus; 4, semimembranosus; 7, 8, gastrocnemius; 9, plantaris; 15, 15, hallucis longus; 16, tendo calcaneus.

to the operator that the artery is not far off. By separating the edges of the incision the vessel may be found, even if not exactly in the direction of the cut. It is very rarely tied here. Below, where the artery becomes more superficial, there is no difficulty in finding it. Care should be taken to avoid the great saphenous vein. The artery is accompanied throughout by two veins, with frequent cross anastomoses, and by the posterior tibial nerve, which is at first on its medial side, but crosses over to the lateral side, below where the peroneal artery is given off. A section of the nerve paralyzes the plantar muscles.

The deep layer of muscles is constituted by the tibialis posterior, the flexor digitorum longus, the flexor hallucis longus, and the popliteus. The latter muscle is confined to the proximal part of the leg, arising by a rounded tendon from the groove above the lateral condyle of the femur, and passing obliquely inward to the tibia. It is believed to be homologous with the pronator teres of the arm, and, like that muscle, assists in rotating the segment and in bending the joint. All the other muscles terminate in tendons which pass down behind the medial malleolus into the foot. Besides a considerable origin from the intermuscular septum, the tibialis posterior and flexor digitorum longus arise from the tibia; the flexor hallucis longus from the fibula. As the tendons pass downward those of the flexor digitorum longus and the tibialis posterior twist around each other, interchanging places, so that at the ankle the latter is nearest the bone. (See article *Foot.*)

Within the fibers of the flexor hallucis longus the peroneal artery runs close to the fibula, and is therefore often wounded when that bone is fractured. The artery may be of larger size than the posterior tibial, and may take the place of the anterior tibial. At its upper part it is so surrounded by fibrous structures that aneurysm of it is extremely rare. It is also so well protected by the fibula that it is rarely wounded except in fracture of that bone. It is still more difficult to reach for ligation than the posterior tibial, but this may be done by detaching the fibular origin of the soleus and raising the flexor hallucis longus.

FRANK BAKER.

Legumin.—One of the characteristic proteins of the pea. Legumin is of significance from the fact that it has been extensively studied in investigations upon the structure of the protein molecule. F. P. U.

Leguminosæ. (*The Bean Family*). As here considered, this family includes the three subfamilies *Papilionaceæ*, *Cæsalpiniaceæ*, and *Mimosaceæ*, regarded by many botanists, and probably correctly, as distinct families. It comprises nearly 450 genera and about 6,000 species, distributed through all except very cold regions and exceedingly numerous and abundant in most tropical districts. When its general structure, chemistry, physiology, and adaptability to environment are considered, it appears to stand at the head of the vegetable kingdom. Its economic importance is of the greatest. It contributes some of the most highly prized and durable timbers, especially for cabinet purposes. Many species are so rich in tannin as to be valuable tanning agents and very many of its dye-stuffs, like logwood and indigo, have been utilized. Acacia, Senegal, Mesquit, and Tragacanth gums are elsewhere described in this work. Peanut oil is the type of a number of useful fixed oils. Tonka is a valuable perfuming and flavoring agent. Tamarinds, ingas, and other fleshy fruits are important edible products. Most of the richly albuminous fodders, like clover, alfalfa, lupines, and vetches, are yielded by this family, especially by the first-named subfamily, while peas, beans, lentils, peanuts, soja and fenugreek, in the same group, are equally important as albuminous human foods. Medicinally, the Calabar bean, senna, broom, liquorice, jequirity, araroba, Jamaica dogwood, balsams of Peru and tolu, copaiba and erythrophlœum are mere illustrations of a vast number, especially of local employment. *Ononis spinosa* L. and other species of Ononis, household diuretics, and Moussena (*Albizzia anthelmintica* [Baill.] Courd.), an anthelmintic bark treated in the preceding edition of this work, may also be mentioned.

Poisonous species are very numerous. Many of the poisonous constituents are glucosides or alkaloids, readily isolated, their activities not at all uniform. In other cases, as of abrus and locust, they are albuminoids, very difficult of isolation. In some noted cases, as that of the loco-weed, they are absolutely

elusive. Even in such edible seeds as the pea and the bean there exists some unknown principle which renders them injurious when used to excess, and which causes inflammations and loss of the cutaneous appendages, even of the hoofs. This effect is very noticeable in the case of Leucæna and results in a well-marked deformity in the horse, the "cigar-tail," characterized by the complete loss of the hair of the tail. This family is capable of further very extensive exploitation in the interest of materia medica.

HENRY H. RUSBY.

Leidy, Joseph.—Born in Philadelphia, Pa., September 9, 1823. He received the degree of M. D., from the University of Pennsylvania, in 1844. He then began the practice of medicine, but in 1846 he discontinued it in order to devote his time exclusively to teaching and research work. In 1847, in association with Prof. William E. Horner of the University of Pennsylvania, he gave a private course of anatomical lectures. In 1853, upon the death of Dr. Horner, he was elected to the full possession of the Chair of Anatomy; he was also chosen Dean of the Faculty. Both of these positions he held until the time of his death, which occurred April 30, 1891.

Dr. Leidy was an accomplished draughtsman and an enthusiastic paleontologist. As early as 1847 he published a paper "On the Fossil Horse of America," in which he clearly established the former existence of a diminutive species, for which he proposed the name of "Equus Americanus." This subject, with later discoveries, in the hands of Thomas H. Huxley and Othniel C. Marsh, has been largely used as a demonstration of the theory of evolution. In 1880 Prof. Leidy received the Walker prize of $1,000 from the Boston Society of Natural History, and in 1884 he also received the Lyell medal from the Geological Society of London as a recognition of his valuable contributions to paleontology. In 1886 Harvard University conferred on him the degree of L. L. D. It is said that the titles of his published works exceed 800 in number. A. H. B.

Leishmania.—*Piroplasma, Herpetomonas.* A genus of protozoans. These occur principally in endothelial cells but are also found in leucocytes and the peripheral blood of mammals as small, oval, cytoplasmic masses with tropho- and kineto-nuclei; in cultures they develop into flagellate bodies. Three species are known in man: *L. donovani*, which is carried by the bedbug and causes kala-azar; *L. tropica* is found in tropical sores; *L. infantum* occurs in dogs and man. See *Protozoa*. A. S. PEARSE.

Leishmaniasis.—Under this head will be considered: Indian kala-azar, Infantile kala-azar, Oriental Sore, and Espundia.

INDIAN KALA-AZAR.—This is a chronic specific febrile disease caused by *Leishmania donovani* R. Ross, 1903. Indian kala-azar is endemic in parts of India, especially in Assam, Calcutta, and Madras. It has also been found in Arabia, Ceylon, Burma, Indo-China, the Sudan and Egypt.

The name kala-azar means black fever and was first given to a very prevalent and destructive (supposedly malarial) cachexia found endemic in the Garo hills when first occupied by the British in 1869. This disease continued to spread, following the lines of human intercommunication into Assam in 1889 and was then studied by Giles who concluded that it was due to ankylostomiasis. The parasite *Leishmania donovani*, which has later been recognized as the specific cause of kala-azar was found by Sir William Leishman in the spleen of a soldier who died in Dum-Dum, but he did not publish his discovery until 1903. In July 1903 Donovan observed the same parasite in material obtained by splenic puncture. The parasite is therefore now known as *Leishmania donovani* or Leishman-Donovan bodies. Rogers in 1904 while experimenting with the parasite observed it to develop into a flagellate organism in splenic blood diluted with sodium citrate solution, and incubated at 22° C. Patton found that the parasites could be demonstrated in leucocytes of the peripheral blood.

Etiology.—The cause of the disease is now known to be Leishmania donovani but there still remains some doubt as to the manner in which the parasite is transmitted from man to man. Like other forms of Leishmaniasis the disease is directly dependent upon

FIG. 3726.—*Leishmania donovani* in scrapings from the spleen.

the introduction of an infected human into the district. Whenever introduced it spreads very slowly but in the direction of human intercommunication. It runs in families. Dwellings become infected and then persons who take up their residence in them are likely to become infected, though the family who infected the house may have been away at least as long as two months. The work of Major Leonard Rogers and Captain Patton goes far to indicate that this particular Leishmania is transmitted by the bedbug, *Cimex lectularius*.

Symptoms.—The incubation period is difficult to determine but is generally considered to be long. It is variously stated to be from three weeks to several months.

An early symptom is chill which may be repeated daily for a time. Irregular, high, remittent fever is present and very soon begins to show two remissions per diem. This double remission is considered quite characteristic. Headache, nausea, and vomiting are unusual. This initial stage terminates in about three weeks with decline or disappearance of the fever. The spleen and liver have enlarged greatly by this time and the patient begins to appear anemic and cachectic.

Other cases begin with gastrointestinal disturbances and dysentery but have little or no fever.

After the decline of the fever there is an apyrexial stage during which, however, there may occasionally be slight rises of temperature. After a few days or weeks there is relapse of fever running a similar course to that of the initial stage.

These periods of pyrexia and apyrexia alternate, the patient becoming more and more anemic and cachectic. The liver and spleen continue to enlarge until finally their size gives rise to great prominence of the abdomen. The patient becomes emaciated and very weak. There is pigmentation of the skin and mucous membranes giving rise to the name kala-azar, or black fever.

Finally the patient dies of asthenia or more frequently of some fortunate complication. It is suggested by Castellani and Chalmers that the great reduction in the number of the polymorphonuclear leucocytes renders the patient more susceptible to infection by the various pyogenic bacteria, streptococci, pneumococci, etc. The average duration of the disease is about ten months.

Leucopenia progresses from the very first until finally the total number of cells may be as low as 800 or 600 per cubic millimeter. The polymorphonuclear leucocytes both neutrophile and eosinophile finally almost disappear giving rise to relative increase of mononuclear cells.

The red blood cell count diminishes as the disease progresses, the hemoglobin reading reducing at about the same rate. The cell count gets as low as 2,000,000 at the end of the disease.

Parasitology.—The parasite reproduces in the endothelial cells especially of the liver, spleen, bone marrow, and the lymphatic glands, but to some extent in those of other organs also. Reproduction is by simple fission. Leishman states that one cell may contain upward of 220 parasites. Cells rupture giving rise to free parasites in the peripheral circulation, either free in the plasma or in the polymorphonuclear and mononuclear (endothelial) leucocytes. They are stained well by the polychrome stains, Leishman's Giemsa's, Wright's, etc. It is round, oval or pyriform measuring 2 to 3.5 microns in length by 1.5 to 2 microns in breadth. It contains a large pale staining chromatin granule and a long narrow deep staining one. The protoplasm stains blue.

Pathology.—At autopsy the extreme emaciation attracts attention as well as the prominent abdomen containing the enlarged spleen.

The spleen is greatly enlarged and the capsule is thickened. Smears from the cut surface show enormous numbers of parasites chiefly in endothelial cells and macraphages.

The liver may be enlarged but on microscopic examination it is observed that the liver cells are atrophied while the intralobular capillaries are dilated and contain macrophages filled with Leishmania.

The bone marrow contains numerous parasites and the yellow marrow is converted into red marrow.

The *prognosis* is bad. The mortality is seventy to ninety-eight per cent. Those who recover from secondary infection may recover also from the kala-azar thanks to the leucocytosis produced by the pathogenic infection.

Treatment.—Manson and Low recommend treatment with atoxyl three grams every other day. Manson had two successful cases. Rogers and Castellani and Chalmers recommend massive doses of quinine sixty to ninety grains a day. Manson has advised antimonial preparations. It is not likely that any drug now used has any specific action.

Infantile Kala-azar (Ponos).—Infantile kala-azar is a chronic specific disease caused by *Leishmania infantum* Nicolle, and clinically closely resembling Indian kala-azar but occurring in childhood.

Pianese announced in 1905 his discovery of bodies resembling the *Leishmania donovani* in the liver and spleen of children in the south of Italy, dying from a type of infantile splenic anemia thought to be the same as that described by Fede several years previously. Later Nicolle and Cassuto observed the parasites in spleen smears from a child in Tunis suffering from irregular fever and splenomegaly which they called infantile kala-azar. The disease has later been found in Malta, Sicily, Lisbon, Greece, Corfu, Algiers, Turkestan, the Sudan. In fact it is found in much of the country in the Mediterranean basin.

Etiology.—Nicolle in 1908 successfully inoculated a dog intrahepatically and intraperitoneally with blood from the spleen of a case of kala-azar. Since that time successful inoculation of dogs and some other animals have been made by many others. Nicolle made the important discovery in 1908 that natural infection also occurred in dogs of Tunis and found 1.8 infected in the spring. Since his discovery dogs have been found infected wherever the disease is endemic in children and sometimes the per cent. of infection is quite high. Twenty-seven dogs out of thirty-three in Bordonaro near Messina were found infected by Basile by examining the bone marrow. He found infected dogs in every house in which Gabbi had previously found kala-azar. He also found infected dogs in houses where subsequently infantile kala-azar developed.

As a result of the extensive investigations that have been conducted it seems reasonably certain that canine kala-azar and infantile kala-azar are the same disease.

The infection has been experimentally transmitted from dog to dog by the dog flea, *Pulex serraticeps*. Basile found *P. serraticeps* in the bedclothes and mattresses of families who kept dogs in the house. He collected these fleas and some from the dogs and carried them to Rome where he was able to experimentally infect dogs with them. The disease therefore is most likely transmitted to man by the *P. serraticeps* and perhaps other fleas. On the other hand Ctenocephalus felis was found by Patton not to be capable of serving as host to Leishmania donovani—the parasites dying out in them in a few hours. Basile, 1914, reports further on the successful inoculation of fleas from dogs and transmission of the infection from dog to dog. Sergent obtained transmission from dog to dog when the fleas were kept at 22° C., but recently the accuracy of all these experiments have been questioned especially by Wenyon. It is suggested that the flagellate parasites found in the supposedly infected fleas were in fact natural flagellates of the flea and not Leishmania and that the apparently successful inoculation of dogs was more likely natural infection occurring where the disease was endemic. The fact remains, however, that in all the endemic centers of the Mediterranean human kala-azar, there also exists intimately associated with it canine kala-azar, the parasite of which cannot be differentiated from that of the former.

The *symptoms* of the disease are very similar to those of Indian kala-azar. It occurs chiefly in children between the ages of about six months and six years. The period of incubation has not been definitely determined but is from at least three weeks to several months according to the best information.

During the initial period there is irregular, remittent, sometimes intermittent fever, associated with gastrointestinal disturbances. The stools contain bloody mucus sometimes in great quantity and there is usually vomiting.

The first period gradually runs into the second in which the anemia, emaciation and splenic enlargement are prominent symptoms. The fever continues but may be less than it was earlier. The pallor attracts attention. The patient is usually strikingly white in appearance, "white pallor."

The number of erythrocytes is reduced and the reduction in the percentage of hemoglobin is greater. Though polychromatophilia is present there is little poikilocytosis or anisocytosis. Leukopenia is the rule but it is not as marked as in Indian kala azar. Sometimes the number of leucocytes may be normal or actually increased. Nicolle found the coagulation time abnormally long.

The spleen is hard and usually reaches enormous size. The liver is also enlarged but to lesser degree than the spleen. The few cases that recover have less enlargement of these organs. Emaciation becomes very great during this period. It is general except for edema which may involve the hands, feet, scrotum, etc. Hemorrhages from gums and nose may occur.

During the third or terminal period there is cachexia, marasmus, and increase of the earlier symptoms until the child finally dies. The spleen and liver, however, usually reduce somewhat in size as a result of the profound diarrhea that is present at this time. The end is often brought about by complications.

The postmortem findings are practically those of Indian kala-azar, which see.

The *prognosis* is very unfavorable but a very small per cent. of cases do recover. It is possible that it will be found that a larger percentage of cases recover whenever more of the mild cases are recognized.

Treatment.—There is no specific treatment of service. Quinine is often given. It is thought that patients are benefited by removal from the endemic region.

Cutaneous Leishmaniasis (Oriental Sore).—*Synonyms:* Granuloma endemicum, Furunculosis orientalis, Pian-Bois, Sudan nodules, Leishman nodules, Parasitic granuloma, Delhi boil, Aleppo boil, Biskra button, Bagdad boil, Bouton d'Orient, Chancre du Sahara, Endemische Beulenkrankheit, Bess-el-Temur.

This is a specific ulcerative affection occurring in many tropical countries and caused by Leishmania tropica Wright.

It occurs in endemic foci in practically all tropical countries especially in the larger cities. At certain seasons of the year most any abrasion of the skin is likely to become a "bouton."

Etiology.—The specific cause is infection of an abrasion with *Leishmania tropica* Wright of which there must be several varieties. Various insects including the common house-fly have been thought to transmit the infection but since it is known to be autoinoculable it is quite probable that direct or indirect contagion is an important factor.

Symptoms.—After an incubation period of from a few days to several weeks or months during which attacks of irregular fever occur, one or more pruriginous spots appear on the skin of the uncovered parts. These may be mistaken at first for insect bites. An inflamed areola appears later becoming indurated. The papules become the size of a pea or bean. After two to four months ulceration begins. This is superficial but slowly spreads and finally reaches one inch or more in diameter. Healing sets in in from six to twelve months.

The *diagnosis* must be based on the presence of *Leishmania tropica* in the scrapings.

Treatment.—The disease gets well without treatment. Many drugs have been tried as local applications without certain results. Recently Ferra, 1913, has been very successful in treating the disease occurring in Brazil, with one per cent. solution of antimony tartrate in physiological serum sterilized by filtration through a Berkefeld filter. He gives 5 c.c. intravenously each day for five successive days. The cutaneous lesions heal quickly. This method of treatment, "Brazilian method" has also been found to sometimes give marvelous results by Da Silva, 1914.

Espundia (Naso-oral Leishmaniasis).—Espundia is a chronic ulcero-granulomatous disease affecting the skin and mucosa of the mouth and nose caused by *Leishmania tropica* Wright var. americana.

The disease has been known in South America for many years. Breda found it in Italy in immigrants returning from Brazil. It was described as occurring in Peru by Escomel in 1911. The Leishmania has been successfully inoculated in monkeys by Splendore. He found that in cultures the flagellum was longer than in Leishmania tropica and Laveran and Nattan Larrier, 1912, created a new variety, *L. tropica* Wright 1903 var. americana Laveran and Nattan-Larrier. No doubt further information will show that the disease is much wider spread than is now known.

The first *symptom* is the "espundial chancre" which occurs on some exposed part of the body. After slow development the ulcer breaks down, giving rise to an ulcer with abundant flow of purulent excretion. This heals after several months or a year or two. Following this the characteristic lesion or lesions appear in the mouth and nose. An ulcerated granuloma may invade the hard and soft palate, the gums and the mucosa of the lips and cheeks. Marked deformity is produced by destruction of the cartilages of the nose. The disease lasts for many years until the patient finally becomes cachectic either from the disease or from intercurrent disease.

There is no specific *treatment.* In the light of recent information the antimony tartrate should be tried. Five cubic centimeters of a one per cent. solution, intravenously each day for five days, is the usual treatment. Excision of the primary "chancre" is recommended. If it can be done before invasion of the system has occurred it may be of service.

C. C. Bass.

Lemon.—See *Limo.*

Lentigo.—*Synonyms:* Freckle, Ephelides; *Fr.*, Ephelide; *Ger.*, Sommersprossen.

Definition.—Lentigo (from the Lat. *lens*, a freckle), commonly called "freckles," is a condition of the skin consisting of a deposition of pigment in the epidermis which appears in the form of fawn-colored or brownish spots, irregular in outline, varying in size from a pin-head to a dime, and met with for the most part on the face and back of the hands or parts exposed to the sun. More strictly speaking, it is an aberration of function whereby the normal pigment of the skin is deposited in increased or abnormal amount in certain clusters or circumscribed areas of the prickle-cell layer.

Symptoms.—The lesions are subject to great variation in number, size, and color, the latter varying from a yellowish to a dark brown. The most frequent locations are over the bridge of the nose, adjacent surface of the cheeks, over the malar bones, the dorsal surface of the hands and forearms. Sometimes they appear on parts of the body habitually covered by clothing, as cases recorded by Crocker[1] and Pusey[2] in which the lesions first appeared on the internal surface of the thighs. Persons with reddish hair are especially prone to this affection. Dark-complexioned people or those who tan readily are seldom affected, while in mulattoes the condition is not infrequently seen. The disease is most commonly seen in youth and adult life, seldom in infants or in old age. When present in the latter it is usually marked by degenerative epidermal changes, as in keratosis senilis. It is a condition of sunshine on which it depends and appears consequently for the most part during the summer months, disappearing or greatly fading away in the winter. Only certain people are susceptible to the disease. In general, lentigo is looked on as a disfigurement only and as a rule it remains a harmless condition

nor are degenerative changes, such as are observed in xeorderma pigmentosum of common occurrence; at the same time, there is much in common between these two diseases and much pertaining to their etiology that remains unknown. A distinction is made between lentigo and large, patchy areas of pigmented skin known as chloasma. In mulattoes I have seen the contiguous mucous surfaces to be involved.

Histopathology.—The changes found in lentigo are limited to the epidermis and consist in the deposition of pigment granules of melanin in the prickle-cell

Fig. 3727.—Freckles.

layer. It is similar to that found in normal pigmentation of the skin and differs only in increased amount and its irregularity of distribution. The pigment is free from iron, and therefore a true melanosis in distinction to hemosiderosis in which the coloring matter is derived from the blood and gives an iron reaction. Unna[3] in an examination of three cases found the pigment granules distributed both intra- and intercellularly, and with a copious pigment deposit; the cells became softer and finally lost their spinous processes.

Etiology.—There seems little ground to doubt that the lesions in lentigo are stimulated by exposure to the sun and that the actinic or chemical rays of the solar spectrum are responsible for their appearance. This does not explain why all skins do not respond in like manner to these rays, nor why in certain cases lenticular depositions of pigment are followed by multiple carcinomata as in xeroderma pigmentosum. We know that those of reddish hair are especially subject to freckles and that degenerative changes in the skin are more frequent in those persons whose skin burns instead of taking on the condition of tan on exposure to the direct rays of the sun. The red or heat rays do not act as an exciting cause. The blending of the Caucasian with negro blood likewise favors this pigment anomaly. The underlying cause of lentigo is an inherited predisposition, the exact nature of which remains unknown.

Treatment.—From the foregoing it may be readily seen that the cure of lentigo is effected by avoidance of contact with the actinic rays. Protection by avoiding the direct rays of the sun, wearing broad-rimmed hats, sun umbrellas, and gloves are means that readily suggest themselves. The color of these protectors is of importance, thus it is known that red, orange, or colors in the lower end of the spectrum are not inimical and therefore should be selected as light screens. Temporary relief can usually be obtained; and sometimes the tendency to the formation of freckles, which is observed in childhood, disappears during the second or third decade of life. Most of the preparations recommended for their removal act by causing free desquamation of the epidermis and consequently the removal of the rete cells. The most efficient application is the mercury bichloride in the strength of from 1–200 to 1–500 parts of water or alcohol. Lactic acid in the strength of from 1–5 to 1–20 parts of water is also used. Salicylic acid from 5–20 per cent., used alone or combined with an equal quantity of resorcin, made into a paste and applied for several hours or until a sufficient reaction has taken place, is also used. Care should be taken not to apply this to delicate skins or to allow it to remain too long. In most cases I have found it sufficient to direct the patient to avoid the sun as much as possible and to apply the following at night:

℞. Sulph præcipitati. 15.0 gm.
Acidi borici..... 3.0
Glycerini,
Alcoholis āā ad. 90.0
Misce et Signa.—Shake well and apply with finger at night, wash off with warm water and soap in the morning

Finally, I believe it expedient to advise against undue sun exposure on the part of those whose skin does not respond normally by taking on a protecting coat of tan. William Thomas Corlett.

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Leomopsilla.—A genus of fleas, Siphonaptera. *L. cheopis*, the commonest rat flea in tropical countries, is of particular interest because it carries bubonic plague. It has been found in several species of rats, man, and other animals. See *Insects, Parasitic.* A. S. P.

Lepidoptera.—The order of insects which includes the butterflies and moths. Many caterpillars are known to be poisonous. They produce skin eruptions and other disorders. See *Insects, Poisonous.* A. S. P.

Lepidoselaga.—A genus of gadflies, *Tabanidæ*. The body is covered with metallic scales. Like all this family these insects are fierce blood suckers. See *Insects, Parasitic.* A. S. P.

Leprosy.—*Synonyms*: Lepra; Elephantiasis Græcorum, Hebræorum; Leontiasis; Satyriasis; Ophiasis; Tzaraath (Hebrew); Kushta (Indian); Jusam Dolfil (Arab.); Fa-fung, Ta-ma-Fung (Chinese); Boasi (South American); Lehata (South African, Bantu); Nsudi (Congo); Lebbra (Italian); La lepre (French); Radesyge, Spedalskhed (Norwegian); Aussatz (German).

Definition.—Leprosy is a disease of systemic type, considered contagious and due to the *Bacillus lepræ*, which in its development attacks the various tissues and organs of the body, producing structural changes in the skin, mucous membranes, nerves, muscles, bones and other tissues and organs, causing more or less alteration and destruction of the areas involved, at times producing mutilation and deformity and ending often in insanity and death.

History, Occurrence, and Commentary.—Leprosy is as old as history. By various leprologers the origin is referred to the banks of the Nile. Biblical history certainly notes its importance even if the diseases called leprosy were numerous and confusing. Even more modernly many scaling diseases were embraced under the term of *lepra*. Almost all countries have had enough cases to attract attention and in some the disease has been widespread enough to have required rigid measures of control.

The Crusades are charged with the introduction and spread of leprosy in Europe from the eighth to the twelfth centuries and leproseries abounded in Continental Europe in the Middle Ages. Traces of the ostracism of lepers are still extant in the ancient churches and cathedrals where occasionally is found a truncated vestibule opening into the chancel but separated from the body of the church; through these corridors lepers could see and hear religious service without being seen.

To-day humanitarian practices prevail in the care of lepers, except, perhaps, in China where the tinkling bell yet warns the passerby. In China it is estimated that over 1,000,000 persons are afflicted with leprosy. Japan had about 20,000 a little over a decade ago. India is given 200,000; South America from 20,000 to 30,000. Leprosy is known to exist in almost all countries; Russia, Norway and Sweden, the Hawaiian Islands and Australia are especially to be noted; in the West Indies, islands in the Pacific, including the Phillippines, with some thousands, and even the island of Guam. In North America, Louisiana, Texas, Mississippi, Alabama, Florida, and Minnesota are endemically affected and more than one-third of the United States has from time to time recorded cases. Canada is not free, cases being isolated at Tracadie and Darcy Island.

The two leprosy conferences, Berlin in 1897 and Bergen in 1907, have added interest to the study in leprosy control and most countries have taken measures. Louisiana and Massachusetts have institutional care and separate State provisions; California, New York, and Minnesota have some supervision. The United States Government has spent considerable sums on leprosy in its territorial possessions and recently Congress has been solicited for similar activity at home.

In India, Australia, and other British possessions, systematic care is practised. The same obtains in Japan, some of the West Indies, Hawaii, and in many other countries.

Etiology.—The *B. leprœ* has been generally accepted as the cause of leprosy. The transmission of the organism is an open question. The introduction of the bacillus through the nasopharynx has many adherents.

The discovery of the *B. leprœ* in the mosquito (*Culex perstans*) by Goodhue and in the bedbug, together with the experimental work of Allen J. Smith in infecting bedbugs point to the possibility of a carrier. The rat leprosy, studied by Brinckerhoff and others, suggests another source.

The community occurrence of leprosy among near relatives living or socially brought together; the occasional occurrence of the disease in those working with leprosy (Father Damien at Molokai and Father Boglioli in New Orleans) argue in favor of its contagiousness, which is accepted by the majority of those who have had much observation of the disease. Jonathan Hutchinson advanced the theory of fish eating as the cause of leprosy, but this remains unproven in spite of its adherents. Heredity was long held as important in the etiology of leprosy, but no evidence has yet come to prove it. There is as yet no record of congenital leprosy and the careful statistics of the British Leprosy Commission in India showed less than three per cent. of the disease among the children of lepers removed at birth.

In countries where leprosy is indigenous the native born are more often afflicted. Seaboard countries are more exposed to leprosy and, therefore, they are more commonly affected. Climate is a debatable factor, for leprosy occurs alike in cold countries (Iceland, Norway, Russia, etc.) and in warm, though the historical study of the disease shows it to have prevailed more in warm countries.

Pathology and Bacteriology.—The discovery of the leprosy bacillus is attributed to Hansen in 1874; Neisser, working independently, had the same findings, but did not publish them until the following year. The organic lesions of leprosy are held due to the *Bacillus leprœ*, which is described as a small rod bacillus, from one-half to three-quarters of the diameter of a red blood corpuscle in length ($\frac{1}{3000}$ of an inch) and in breadth about one-fifth the length. The bacillus is straight or curved slightly, with rounded ends, and may have its extremities club shaped. It occurs in short chains or beads, resembling the tubercle bacillus. The leprosy bacilli are more numerous than the tubercle bacilli and are more frequently found in clumps and masses in the tissues, and are more readily stained with the usual methods. In doubtful cases cultural experiments establish the differentiation.

Various inoculation experiments have been essayed in animals. Duval, Couret, and Gurd have succeeded in cultivating a chromogenic organism with which successful inoculations have resulted in white mice, white rats, turtles, fish, and monkeys (*Rhesus macacus*). Human experimentation has been rare and doubtful.

The bacillus occurs in the nasopharyngeal and other secretions, the saliva, feces, vaginal and urethral secretions, in the semen, milk, and sweat. The fluid from artificial blisters, and serum drawn from deep tissues and nerve sheaths, have been examined with positive results. In well established cases the scrapings from the skin are full of the bacilli.

Fig. 3728.—Pure Culture of *B. leprœ*. (Duval.)

The preparations in smears from these secretions, fluids, etc., are dried and fixed in the ordinary way, and stained with carbol-fuchsin, as for tubercle bacilli; they are then decolorized with a weak solution of acid (three to five per cent.), completed with alcohol and counter stained with methylene blue. The clumps of bacilli take up aniline stains (Gram method) at a low temperature and retain them tenaciously.

The cultural possibilities of the lepra bacillus are still great, but the uncertainty of the identity of the *B. leprœ* leaves the matter in some doubt.

Woolley (*American Journ. Trop. Dis.*, Feb., 1914, pp. 580-583) reviews the matter with the conclusion that the cultivation of the leper bacillus is not yet proven. Kedrowski, Clegg, Rost, Williams and Rost, Bayon, Duval, and Frazer have each developed methods of culture. It is not unlikely that most observers have worked with mixed organisms and that the future must define the characteristics of the true pathogenic bacillus.

The bacilli are widely disseminate and have been found in all the organs of the body, including the brain and spinal cord.

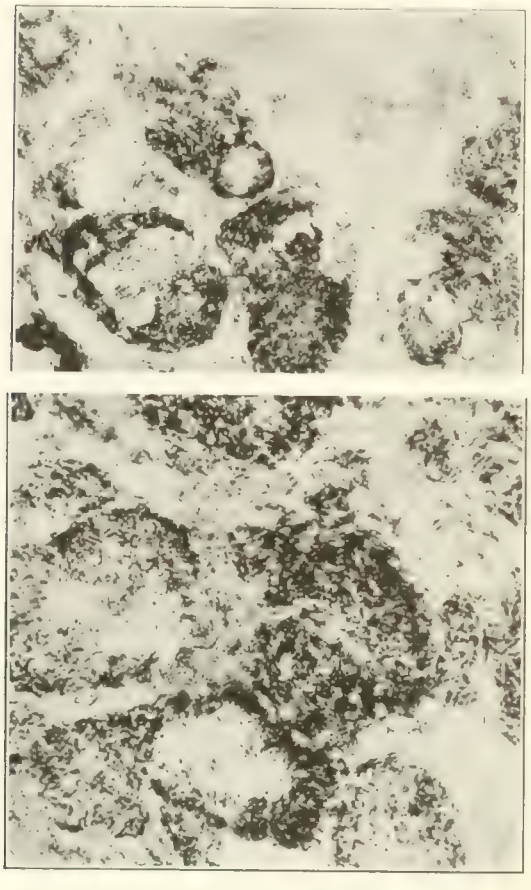

Fig. 3729.—Growing Masses of *B. leprœ* in Excised Bits of Human Leprous Tissue. (Duval.)

The *B. leprœ* gives rise to nodular masses, or lepromata, belonging to the group of granulation tumors. They consist microscopically of a small amount of fibrillar connective tissue with numerous cells of various forms, mostly small, round epithelial cells, spindle formed, and the leprosy cells. These are mostly large round or oval cells, with many nuclei and vacuoles, which contain the leprosy bacilli. These cells are diagnostic and are found most numerously in the tubercles and nodules of leprosy. Unna opposes the giant cell idea of leprosy, attributing these to agglutination of bacilli, which are habitually aggregated in the lymph spaces.

Symptoms and Diagnosis.—The incubation of leprosy is unknown and any fixation of a stated period is mere conjecture. Lepers are usually seen only when the disease is marked. These patients relate the earlier history which gives a varied group of prodromes: as irregular fever, malaise, vertigo, anorexia, epistaxis, neuralgias, pains in the arms and legs and exaggerated function of the fat and sweat glands; the loss of sexual power is related and apprehensiveness of serious illness. There may be marked hyperesthesia of the skin, with areas of pruritus or pain and there may be irregular disturbances of the intestinal tract. Almost all cases show evidence of disturbance of the nasopharynx in the peculiar metallic vocal resonance, attributable to early infiltration of the mucous membrane in the upper air passages. The excoriation of the septum is an early and almost constant symptom which has led to the opinion that this may be the initial lesion of the disease.

There can be no stereotyped classification of leprosy and when the attempt is made it is apt to be confusing because the exceptions are more numerous than the rule. It is easier to study the presenting evidences and to group them accordingly, according to the degree of involvement of one or more organs. The salient points of diagnosis consist in the recognition of the stamp of the disease, which is always suggested by the dusky hue, the swollen skin, the overhanging eyebrows and the raucous voice. The hands have a thinned epidermis and an altered color. The presence of tubercles or nodose areas on the skin of the face, about the orifices, is strongly suggestive.

We may speak generally of cutaneous and of trophic leprosy, though either may take on the form of the other.

Cutaneous leprosy may be macular, tubercular, bullous, pigmentary, nodose, scaling, ulcerative; trophic leprosy is either atrophic locally or generally, or it carries cutaneous lesions with deeper destructive evidences in the nervous system.

Cutaneous Leprosy.—*Macular Leprosy.*—Macular leprosy may occur in three forms. First, as an expression of a general impression of the individual carrying a circulating infection of the disease and its organism. Such an eruption is evanescent; it has all the characteristics of an erythema multiforme of toxic type and the eruption is not characteristic of leprosy. Here the lesions are of various sizes, bilateral and symmetric, general over the whole body, and are light red, level with the skin, fade on pressure, have no fixed pigment and may be quite hyperesthetic so far as itching, heat, and hypersensibility are concerned. Such macules may disappear entirely or they may continue *in situ*, giving gradual place to infiltrated and even nodose lesions in the same areas. More often they disappear and may recur months afterward. With such evidences the general symptoms of leprosy are associated.

Macular leprosy may be pigmentary from the start. Over the buttocks, hands, face, and legs, particularly, the eruption shows in reddish-brown macules, more or less rounded in outline, level with the skin, and persistent in all of these characteristics.

The true type of macular leprosy is the most characteristic. Ovoid macules, varying in size, appear on the face, over the shoulders, over the arms and forearms, over the legs, more or less scattered, edges elevated and centers depressed; often the edges are highly pigmented, brown or purplish, and the center is of normal color or even a dirty white.

The last named macules are anesthetic; the others are not. The anesthesia is more marked at the borders. More than this, in the borders of the last-named macules, it is usually easy to demonstrate the lepra bacilli; in the first two varieties of macules, it is almost impossible to find any bacilli—arguing, as has been suggested, that the eruption is rather an exanthem than a deposit.

Macular leprosy must be differentiated from *syphilis* and from *erythema multiforme*. From the first the macules may be easily distinguished by their preference for the extensor surfaces, by their large size and by the peculiar dusky color in the pigmentary forms. Macular syphilis is not infiltrated.

From erythema multiforme, the diagnosis is made on the more established eruption, lasting weeks or months, and in the pigmentary and infiltrated types by the fact that in both the lesions do not fade on pressure. Sometimes iodism produces infiltrated lesions resembling leprosy, but here the whole lesion is turgescent and highly inflamed, and therefore red and not dusky-brown red.

Tubercular Leprosy.—The tubercle of leprosy is of two forms. The large tubercle is found about the nose, on the chin, cheeks, in the pendulous portion of the ear, and sometimes on the hands and on the legs. The color of these lesions is characteristic—brown red. They are firm, rounded masses, deep set in the skin, not uniform in size and with no tendency to disintegrate while the general condition of the patient is good. The lesions are almost invariably anesthetic.

Lupus and *syphilis* may be confused with this form of tubercle. In lupus the lesion is purple, granulomatous in consistency, and ulcerating as soon as the tubercle is mature. The general symptoms in leprosy (nasopharyngeal and laryngeal, particularly) are ordinarily concomitant. In syphilis the tubercles are smaller, grouped in crescentic formation, and scar in ulcerating, with marked and characteristic pigmentation.

The small tubercle of leprosy is quite different. Here the lesions cluster close, like small pea-sized bits of beeswax embedded in the skin. Over the backs of the hands, the chin, the borders of the lips, and the cheeks are the sites of predilection. The lesions are a dirty yellow. This type of tubercular leprosy is usually rapid in its course, presumptively because the lesions in the skin are probably only the expression of a general tubercular condition of the viscera. These lesions are likewise anesthetic.

Only *xanthoma* and *disseminate tuberculosis* need to be considered in differentiation. Xanthoma presents flat tubercles, deep seated, bright yellow, smooth and usually lissome to the touch. Stretching the skin in xanthoma shows the streaks or connective tissue in the striæ of the lesion; stretching the skin in leprosy only intensifies the waxy appearance of the tubercle. Xanthoma at times is painful; leprosy is anesthetic.

Tuberculosis of the miliary form may be disseminate in the skin and may be found in the areas in which tubercular leprosy is found. The lesions are in closer formation; usually occur as smaller tubercles and usually are found about the joints rather than at the peripheral extremities. Confusion often arises in these two conditions occurring on the face, but as the organisms of leprosy and of tuberculosis can be almost always demonstrated, this method, even carried to cultural procedure, will finally decide.

Bullous Leprosy.—Bullous leprosy must be noted as important, particularly as it is an early form. The lesions come on the hands and feet, over the joints of the fingers, as a rule. The bullæ repeatedly occur at the same spot, until finally the epidermis is lost and bullæ cannot form. Scarring, with mottling pigment, follows. Sometimes necrosis supervenes and the deformity from loss of bones may result. This dermatological evidence is really the expression of a disturbance in the nerve, usually the ulnar, along which may be found, when the bullæ occur, marked thickening or even distinct nodosities along the sheath.

Pigmentary Leprosy.—In some instances the local evidence of leprosy manifests itself in diffuse pigmentation of the face, neck, trunk, hands, arms, and legs. At times the whole body may be so pigmented. The slight mottling is peculiar to this disease and makes the differentiation from the pigmentary evidences in *vitiligo* (in which the demarcation of color is abrupt), in *Addison's disease* (in which the pigment is solid and in selective areas), in *syphilis* (in which the mottling is limited to the neck) and in *mycosis fungoides* (in which the pigment is always cast over or under the premycotic furfuraceous scales).

Nodose leprosy is usually facial, coming on after the diffuse macular form has spread over the face and has persisted. As the skin thickens, rugosities develop and each of these separates into larger or smaller masses, forming nodes. At first there is some mobility, but this gradually disappears until a true satyriasis is established in the facies; and as the disease grows older and the skin roughens, there grows a more and more fixed condition of the skin, until the rugæ resemble the thickened areas so characteristic of the lion's face and from which has been derived the term "leontiasis" as applied to this form of leprosy. Ulcers now ensue as a result of failure in nutrition, and one by one the features change by necrosis until the last stage of a fearful process may end the history of the case by death.

Hypertrophic rosacea, when general over the face, may resemble leontiasic leprosy, but at no time is the mobility lost, and the skin remains soft in spite of hypertrophy. *Chronic edema* may likewise be mistaken for this disease, but in edema the smooth skin with the pitting over all areas makes a clear diagnosis, even if the complication of the keratinous changes in the eyes, and the ulcerative changes in the respiratory tract were not also in evidence to proclaim a more sinister diagnosis.

Scaling Leprosy.—Scaling leprosy is rare. Here the whole skin shows signs of degenerative change, and wrinkling is seen everywhere. No part of the body is free. Thinning instead of thickening occurs, and it is not hard to find the trophic changes of the skin accompanied by like changes in the peripheral nerves and in the mucous membranes of the nasopharynx. The conjunctivæ are also involved and ectropion is common. The muscular changes in the hands are also present and peripheral nerve changes are found at the same time as the general scaling of the body. The skin everywhere has a dirty gray color, with lines of atrophy showing through the scales. The loss of hair over the pubis, in the axillæ, over the body, and of the eyebrows, lashes, beard, and scalp carries further the picture of the atrophic process.

Xerosis in all its forms is easily differentiated by the consistent atrophy in the leprosy of this form. In xerosis the process is as consistently hypertrophic and the more severe the scaling in xerosis the more the tendency is to hypertrophic change.

Ulcerative Leprosy.—Ulcerative leprosy is nearly always found as an expression of nerve destruction and located on the sole of the foot, usually under the fleshy part of the great toe; it may occur at the heel. This ulcer, "neurotic ulcer" in type, is usually one of many symptoms of nerve leprosy, but as an ulcer it shows cutaneous evidence and must be mentioned here. The cylindrical cavity, sharply outlined, rather deep, and the hard and horny edges, with the nauseating odor, are sufficient to make a diagnosis.

When leprosy is advanced, all lesions may give way to degenerative changes, and tubercles or macules may break down, so that ulcerative leprosy may become general. The nasal bones break down; the lips excoriate and slough off; fingers drop; toes are spontaneously amputated; the legs or arms show areas of necrosis, and finally the terminal members one by one may fall.

Papular Leprosy.—In the various exacerbations of leprosy, particularly when the lesions begin to break down, when the toxins are liberated, or the masses of dead bacilli are sent into the circulation, there is frequently a rise of temperature, producing the "fever of leprosy," now recognized as an entity. With this process a general eruption of lenticular papules appears. This is the only form of papular leprosy so far known, and it is questionable if it may properly be called papular leprosy, as the papule is really only an evanescent exanthem, disappearing with the defervescence of the attack. The papules

are free of organisms and are purely exudative in type, inflammatory and hyperesthetic if the sensation is disturbed at all.

Trophic Leprosy.—*Atrophic Leprosy.*—Atrophic leprosy is of nerve origin, but with cutaneous expression usually referred to the extremities. The whitlow, atrophy of the skin of the hands and feet, loss of intermediate phalanges resulting in superficial ulcers and in deformity, the scarring and pigmentation, all are the cutaneous evidences. Syringomyelia may be of other than leprous origin, but the altered or lost sensation, associated with peripheral lesions like the foregoing, the occurrence of contractures of the hand, of atrophy, and of occasional bullæ should lead to a search for the bacilli for a differentiation.

Trophic leprosy may begin with a peripheral neuritis which at first shows only numbness of the fingers, gradually increasing to a complete anesthesia, particularly of the little finger and the third finger. The ulnar nerve thickens and along its course many nodes may be found. Bullæ form on the phalangeal joints, repeatedly recurring until necrosis or atrophy supervenes. Sometimes intermediate joints are absorbed and only one phalanx remains, carrying a grotesquely atrophic finger nail. These symptoms may be preceded by a muscular atrophy occasioning contractures of the fingers, causing them to be drawn into the palms so as to resemble talons, producing the characteristic "griffe," or "claw hand."

Prognosis.—Leprosy is self-limited. Many cases get well spontaneously. Others go on to a conclusion, leaving scars and mutilation, when the disease is worn out. Leprosy lasts for years, usually estimated as averaging eight years. Diarrheas, cerebral degeneration, and nephritis are the usual terminations.

Treatment.—The treatment of leprosy is now looked upon as possibly curative, and cases are being reported as free of all symptoms of the disease, after treatment.

Many remedies have been essayed in leprosy, almost all of them empirical, and these include arsenic, strychnine, hoang-nan, salol, europhen, salicylate of soda, ichthyol, bichloride of mercury, chlorate of potassium, gurgun oil, chaulmoogra oil, red mangrove bark, snake venom and serum derived therefrom, nastin, vaccines, and sera.

Crocker and Hutchinson cured a few cases of leprosy with hypodermatic injections of bichloride of mercury; Fox (G. H.) cured one case with arsenic; Goldschmidt got good results from europhen injected in oil, and other observers have reported various remedies.

Serum and vaccine treatment has been advocated by Carrasquilla in Colombia, by Rost in India, by Kitasato in Japan, and by Duval in New Orleans. None has been of sufficient service to be curative. The *x*-ray treatment has been used with the idea of forcing dead bacilli from local lesions into the general circulation for the constitutional effect. Gilchrist, of the United States Army, at Ft. Oglethorpe, Georgia, first used this treatment, with favorable results, which proved only temporary; a like experience was related in the Phillippines after more extended use.

Treatment resolves itself into the essential fact that the disease is one in which a method of reconstruction is necessary based upon hygiene, full diet and medication. In twenty years' experience the use of chaulmoogra oil is the only medication which has resulted in cure at the hands of the author and over twenty-five cases have been recorded as free of the disease after treatment lasting three or more years.

The treatment may be summarized as follows:

1. Full diet, restricting only indigestible foods as indicated. The disease seems to be affected by no particular diet, and fish has not appeared to be a factor.

2. Baths are essential in the treatment; daily hot baths, as hot as can be borne.

3. The patient needs tonics, febrifuges, and should be watched for intercurrent or complicating diseases as malaria, pleurisy, pneumonia, etc.

4. Strychnine is a *sine qua non* in the treatment and should be given every day in regular tonic doses.

5. Chaulmoogra oil (*Gynocardia odorata*) is the nearest to a specific yet suggested in leprosy. It should be used as *crude* as possible; refined oil loses in the process. The oil should be given before meals in capsules, hot milk, or milk of magnesia. The dose should begin small, three drops three times a day, increased gradually to tolerance which varies from sixty to one hundred and twenty or one hundred and fifty drops at the dose.

The oil may be given in pill form, combining it with ordinary excipients; a very effective way is with tragacanth and common soap.

Heiser has recently reported (*Journal of Tropical Diseases and Preventive Medicine*, November, 1914) excellent results with a chaulmoogra oil mixture, constituted as follows:

Chaulmoogra oil	60 grams
Camphorated oil	60 "
Resorcin	4 "

Of this, two to ten minims (0.12 to 0.6) is injected hypodermically at intervals decreasing in frequency as improvement occurs.

6. Above all things individualize the patient; watch for improvement. If it does not show in three months, wait six months; wait a year, or longer. Keep on driving at the treatment until the patient dies or gets well.

7. When all evidences of the disease are gone, insist on a continuance of the treatment; it may not be necessary but it makes sure.

The sanitary control of leprosy should be practised by every government for the protection of the public and for the care of the leper. Segregation has proved the best method of checking the spread of the disease and this is the basis of practice in most countries.

National leprosaria will solve the question of leprosy incidence and the laboratories give promise of finding some specific. Isadore Dyer.

Leptandra.—*Culver's Root, Culver's Physic.* The rhizome and roots of *Leptandra virginica* (L.) Nutt. Fam. *Scrophulariaceæ*. Leptandra grows very abundantly in open woodlands and copses through the Eastern and Central United States. It is a perennial herb, with simple, straight, erect, slender stems, from two to six feet high, whorled lanceolate leaves, and terminal panicles of long, slender, acute, white or pinkish, densely flowered spikes. The drug is gray-brown or gray-black, from four to six inches long, much branched and crooked, the rhizomes slightly flattened, about one-fourth inch thick. The internodes are characteristically narrowed downward and readily disarticulate. The roots are rather few, sparse, and unbranched. The drug has little odor, but a bitter, resinous, and slightly acrid taste.

The demand for Leptandra is chiefly American. It has, however, been recognized in the Pharmacopœia since the first edition and has of late increased greatly in favor, both here and abroad.

Its important constituent is six per cent. of an irritant resin, of the same general character as those of mandrake and jalap. It contains a little saponin, tannin and gum, and the peculiar bitter crystalline glucoside *leptandrin*, which is soluble in both water and alcohol, and which must not be mistaken for the commerical article so-called.

Our knowledge of the action of leptandra is purely

technical. It is a stimulating laxative or an irritant cathartic, according to its condition and dose. In the recent state it is drastic and even emetic, and poisonous, becoming milder with drying and keeping. It stimulates the intestinal mucous secretion and the dejection of bile, and also the intestinal movements, and is an excellent laxative in doses of one gram, and a purgative in doses of one to four grams. The long list of therapeutic properties attributed to it by the eclectics are not to be denied, but are the result of improved elimination and nutrition. The official preparations are the fluid extract, dose ♏ xv.–lx. (1.0–4.0), and the extract, dose gr. i.–iij. (0.06–0.2).

Each official vegetable cathartic pill contains 0.0015 gram of this extract. Commercial "leptandrin" is the practical equivalent of this extract.

HENRY H. RUSBY.

Leptidæ.—A family of flies which contains at least three blood-sucking genera: *Leptis*, *Symphoromyia*, and *Trichopalpus*. See *Insects, Parasitic.*

A. S. P.

Leptodera.—A genus of round worms. *L. pellio* is an occasional parasite in man. This species usually lives in the soil as an adult; the larva develops in the earthworm. The Hungarian peasants use soil for making poultices and the worms may thus enter the vaginæ of women and live there. See *Nematoda.*

A. S. P.

Leptus.—A genus of harvest mites, *Trombididæ*. These little arthropods are widely distributed in Europe and America. Their natural hosts are insects but they often attack dogs, cats, and other small mammals. In man they cause irritation by burrowing into the skin. See *Arachnida.* A. S. P.

Les Avants.—See *Montreux.*

Letterman, Jonathan.—See *under Army Medical Service, Vol. I, p.* 576.

Leucine.—$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!\rangle$CH. CH_2. CH. NH_2. COOH, α aminoisobutylacetic acid, is produced from proteins by hydrolytic cleavage with acids, by fusing with alkalies, by putrefaction or by the action of enzymes. Leucine occurs as a constituent of protein substances in widely varying amounts. Thus from egg albumin about 6 per cent. may be obtained, from casein about 10.5 per cent., from fibrin 15 per cent. and from hemoglobin 20 per cent. It is found in the wool of sheep, in dirt from the skin and between the toes and some of the disagreeable odor of perspiration of the feet is due to its decomposition products. Pathologically it may be found in atheromatous cysts, ichthyosis scales, pus, blood, liver, and in diseases of the liver and in phosphorus poisoning in the urine. The leucine obtained from proteins by hydrolysis is the l-leucine which in aqueous solutions is levorotatory but in acid solutions is dextrorotatory. Upon heating leucine is decomposed into carbon dioxide, ammonia, and amylamine. In putrefaction or by heating with alkalies valerianic acid and ammonia are formed. When pure leucine crystallizes in thin shining white plates. As obtained from animal fluids and tissues it is always impure and is easily soluble in alcohol and water whereas pure leucine is soluble with difficulty. Leucine is soluble in acids and alkalies and gives crystalline compounds with mineral acids, thus the formation of esters of leucine is employed as a means of separating leucine from other amino acids.

FRANK P. UNDERHILL.

Leucocytosis. In general usage the term leucocytosis is taken to indicate an increase in the number of leucocytes in the circulating blood above that which is normal for the individual. Some authorities prefer the terms hyperleucocytosis and hypoleucocytosis to indicate an increase and a decrease in the number of leucocytes, using the word leucocytosis to mean the normal number of leucocytes. This increase usually affects one type of leucocyte more than any other and terms are used to indicate the kind of cell affected, viz., eosinophilia, polynucleosis, lymphocytosis, etc. It is unusual for the differential count to remain normal in the presence of a leucocytosis of any extent. If one type of white cell is increased in number without increase in the total leucocyte count the condition is known as a relative eosinophilia or lymphocytosis, etc. In leukemia the increase in the white cell count may be due to the influx into the blood of large numbers of pathological cells—myelocytes—though this is not always the case, for such pictures may be seen in other diseases. Naegeli mentions a case of puerperal pernicious anemia with a leucocytosis of 30,000 of which twenty-five per cent. were myelocytes.

The normal number of leucocytes varies within quite a wide range in healthy adults (5,000 to 10,000). Individuals in a poor condition of nutrition but with no special disease have a low leucocyte count, with a reduced percentage of polynuclear cells, while those in vigorous health have a high leucocyte count, even approaching a slight leucocytosis, with an increased percentage of polynuclear cells.

The estimation of the number of leucocytes is of itself of little value in the diagnosis and prognosis of disease but may be of tremendous value when considered along with other data, especially in surgical conditions when there is a question of operation. It should *always* be supplemented with a differential count of the leucocytes in a stained smear.

It is highly important to keep in mind the fact that a leucocytosis may be physiological.

VARIETIES OF PHYSIOLOGICAL LEUCOCYTOSIS.—(1) Digestion, (2) pregnancy, (3) new-born, (4) after exercise, massage, and cold baths.

Digestion leucocytosis is of importance because it is so often overlooked. In health after a meal rich in proteins the leucocyte count may rise even as much as sixty per cent. so that it may reach as high as 12,000 in a vigorous person. The increase is chiefly in the polynuclear cells. The daily variations of the leucocyte count is probably due in part to the effects of digestion. In certain diseases other than those of the digestive tract the digestive leucocytosis may be very marked, as for example in pneumonia. It is absent in sucklings and may be diminished or absent in functional or organic disease of the digestive tract. It is believed to depend upon the chemotactic influence of material absorbed from the intestinal tract.

In *pregnancy* there has been noted a leucocytosis which increases gradually during the period of gestation. It is not so marked, however, as was formerly believed, since many of the earlier counts were based on faulty technique. It is frequently absent in multiparæ who usually show only a high normal count. It is probably due to the general acceleration of metabolic processes which takes place at this time. During parturition and the early part of the postpartum period the white cells may rise to 20,000, due partly to the loss of blood and partly to the inflammatory reaction.

In the *new-born* the leucocytes may number as high as 32,000 and fall quite rapidly so that by the tenth day they are twenty-five per cent. lower. The increase is chiefly neutrophilic in character. The cause is not agreed upon. There are so many radical changes in environment at the time of birth that it is impossible to fix the cause with any certainty.

Violent *exercise* has long been known to cause

marked increase in the number of leucocytes. It is possible also that the slight daily variations of the white cell count are due to the usual exercise taken. In this class also belong the leucocytosis seen following convulsions and in suffocation. Cold baths regularly cause an increase in the number of leucocytes and there is no doubt that the good effect of baths in typhoid fever is in part due to this fact. Exposure to cold has the same effect.

Varieties of Pathological Leucocytosis.—(1) Infectious, (2) toxic, (3) posthemorrhagic, (4) malignant tumors, (5) cachectic, (6) agonal.

In pathological leucocytosis the process may be considered to be a general one, that is a drop of blood from the ear may be considered a safe index of the state of the blood throughout the body. Leucocytosis may be looked at as a symptom of bone-marrow activity in the same way as the pulse is of cardiac activity. Increase in this activity is pretty generally accepted as being due to chemotactic influences. That is, the presence in the blood of certain chemical substances, produced by infective agents, is capable of exerting either an attractive or a repellent influence upon the ameboid leucocytes. If cells are attracted by such substances, the phenomenon is known as a positive chemotaxis; if they are repelled, it is called negative chemotaxis. This effect upon the cells of the blood may be produced by bacteria or their products—necrotic tissue which has gained entrance to the circulation, and thermal and mechanical irritants. It would seem that different varieties of leucocytes—polynuclear neutrophiles, eosinophiles, lymphocytes—respond to different stimuli; in one instance we have an ordinary leucocytosis—as in pneumonia, in which the polymorphonuclear cells are chiefly increased; in another, as in trichiniasis, an eosinophilia; in a third, a lymphocytosis.

It seems reasonable to conclude that leucocytosis is a conservative process on the part of nature, and represents an attempt to destroy the infectious agent or its product by mechanical means, *i.e.* phagocytosis; or by chemical means—the production of chemical substances (alexins) which act as bactericidal or antitoxic agents. Grabitschewsky states that these processes are both active at the period of maximum leucocytosis.

Just previous to the development of leucocytosis, there is usually a stage in which the leucocyte count is low. This is called by Löwit the *leucopenic* phase. Goldscheider and Jacob have proved that this is dependent purely upon an altered distribution of the cells in favor of the deeper vessels.

Pathological leucocytoses differ from the physiological in being usually of larger extent and of greater duration, and in being almost always accompanied by a relative and absolute increase in the polymorphonuclear leucocytes. There is also a change in the cell structure in certain cells. A small percentage of the polynuclear cells resemble myelocytes, having a nucleus which is on the border line between the two cells. One to three per cent. of the cells have become so altered that they cannot be distinguished from myelocytes. In the determination of pathological leucocytosis it is necessary to avoid apparent leucocytosis and to that end counts are best taken early in the morning, before breakfast.

In the majority of the *infectious* diseases a leucocytosis occurs and the leucocyte count in these conditions is of great practical value to the clinician, both in diagnosis and in prognosis. As a rule, the increase takes place largely in the polynuclear cells. It has been fairly well established that the number of the leucocytes is an index of the patient's resistance while the polynuclear percentage is determined by the virulence of the infection. It must be borne in mind that there is no direct connection between leucocytosis and the febrile state and it is not due directly to bacterial invasion. The leucocytosis is the vital reaction of the bone marrow to the bacterial toxin. When the dose of toxin is overwhelming then the marrow is paralyzed, so to speak, and the result is a leucopenia. For instance, we find that in the most severe cases of pneumonia where the patient does not react there is a low leucocyte count.

In certain of the infectious diseases there is no increase in the number of leucocytes and in these it is believed that the toxins have a special affinity for the bone marrow so that the output of the white cells is diminished. These diseases are typhoid fever, tuberculosis (when uncomplicated), measles, German measles, mumps, influenza, glanders, and acute poliomyelitis. In practically all the others a leucocytosis is the regular finding. In malaria, the leucocytosis is temporary, occurring only during the chill.

Purulent and gangrenous processes usually cause a higher leucocytosis than serous processes. A leucocytosis which increases from hour to hour suggests an acute spreading inflammatory process and its detection is of great value in cases of acute appendicitis in influencing the surgeon regarding his operation and prognosis.

The *toxic* leucocytoses are probably closely allied to the infectious. They follow the administration of organ extracts, collargol, phenacetin, potassium chlorate, quinine, salvarsan, and many other drugs. An increase in the white cell count may result from the toxemia accompanying illuminating gas poisoning, rickets, cirrhosis of the liver, chronic nephritis, and chloroform narcosis. The leucocytoses of the various forms of leukemia possibly belong in this group. After the administration of bacterial vaccines (bacterins) there occurs first a fall in the leucocytes (the so-called negative phase) followed by a rise which persists for a varying length of time.

Following a large *hemorrhage* a considerable leucocytosis appears promptly, usually within an hour. This may amount to as much as 16,000. It may be considered as evidence of the activity of the bone marrow in its efforts to make good the loss. In the presence of continued small hemorrhages the degree of leucocytosis is less but it persists for a longer time.

In *malignant disease* an increase in the white cell count is an inconstant finding. In the presence of ulceration with the accompanying absorption of toxic products it is fairly well marked. Metastases in the bone marrow may cause the production of a blood picture resembling leukemia. Sarcoma, especially lymphosarcoma, is more likely to produce leucocytosis than is carcinoma. An increase in the leucocytes may accompany the anemia secondary to malignant disease.

In *cachexia* a leucocytosis occurs only as a result of the action of the causative condition.

An *agonal* leucocytosis occurs in the final stages of different diseases. It is due in some cases to peripheral stasis, in others, it is thought that the bone marrow just before death loses the power to hold back cells from the circulation so that numerous leucocytes escape together with unripe red cells. In some instances terminal infections may be responsible.

In addition to the above divisions there must be mentioned that exposure to the action of the *x*-rays or to radium results in a diminution of the leucocytes since they first tend to destroy the leucocytes in the circulating blood and later exert an injurious influence upon the bone marrow.

Lymphocytosis is an increase in the number of lymphocytes in the circulating blood and is usually, though not necessarily, associated with a leucocytosis. An examination of a stained film is, of course, necessary for its recognition. The blood of healthy infants regularly shows a lymphocytosis. Pathologically the greatest increase in the lymphocytes is seen in cases of lymphatic leukemia. More moderate increases are seen in typhoid fever, malaria, and per-

tussis and this blood change often persists well into convalescence, the so-called postinfectious lymphocytosis. The lymphocytes are increased after injections of serum and in exophthalmic goiter and in both instances this is thought to be due to toxic action. In many debilitated conditions in the adult, the percentage of lymphocytes is increased, due simply to a diminution in the number of polynuclear neutrophiles. This is merely a relative lymphocytosis.

Eosinophilia is an absolute increase in the number of eosinophiles in the circulating blood. There is a variation of from 25 to 500 (0.5–5 per cent.) per cubic millimeter in the healthy adult blood. Physiologically, eosinophilia occurs in young infants, and in women during the menstrual period. Pathologically it has been reported in a large number of conditions. The most important of these are:

1. Myelogenous leukemia. Very rarely is a case of myelogenous leukemia seen without an eosinophilia and sometimes the number is tremendously increased. The reviser of this article has seen an early case in which the blood showed 60,000 white cells of which ninety-six per cent. were eosinophiles.
2. Scarlet fever may give an eosinophilia up to 3,000.
3. Parasitic diseases of all kinds are apt to be accompanied by an eosinophilia. The parasite is most constant and most marked in trichiniasis in which these cells may number fifty per cent. of the total white count. Eosinophilia has been produced in animals by the injection of extracts of *Ascaris lumbricoides*.
4. In bronchial asthma eosinophile cells are found in the sputum and they are increased in the circulating blood. Serum sickness which shows a certain clinical similarity to asthma is also accompanied by an eosinophilia.
5. The majority of the skin diseases are marked by an increase in the eosinophile cells of the blood. This increase is usually not very marked.
6. Neurasthenia and nervous prostration often show an eosinophilia.
7. Postinfectious. An eosinophilia is seen during convalescence from most of the infectious diseases and some authors are inclined to view an increase in the eosinophile count during the course of the disease as indicative of definite improvement.
8. An eosinophilia is an inconstant finding after extirpation of the spleen, in malignant disease, polycythemia, gonorrhea, blastomycosis, and certain affections of the intestine.

In acute infectious processes the eosinophile cells are diminished early in the disease and in pernicious anemia they are usually very scarce.

Basophilia, an increase in the mast cells in the blood, is a much less common finding. It is apt to follow the injection of foreign sera or proteins and the Pasteur treatment of rabies. It is almost constant in polycythemia while in myelogenous leukemia the number of basophiles may reach very large proportions. Their number normally is so small that no serious attempt to study diseases in which they are diminished, has been made. James Rae Arneill.

Revised by Ralph G. Stillman.

Leucocytozoidæ.—A family of protozoan parasites. The ookinete does not become encysted; the schizonts and gametocytes are alternately free and active or endocellular and passive, the former being trypaniform and the latter ameboid. There is only one genus *Leucocytozoon* which contains several imperfectly known species. See *Protozoa*.

A. S. P.

Leucocytozoon.—*Hæmamœba*. A genus of protozoan blood parasites which is of interest because it shows certain similarities to spirochetes and trypanosomes. Several species have been described from birds. See *Protozoa*.

A. S. P.

Leucomaines.—The term leucomaine has fallen into disuse and therefore at the present time is of little significance. Under the term were formerly included those basic compounds that originate from protein as a result of enzyme action. Similar substances formed from protein by bacterial activity are called ptomaines. Inasmuch as the same substances may arise from protein by the two processes a division between the two groups is imperfect and unsatisfactory. Leucomaines were divisible into four groups, (1) the purine group, (2) the pyrimidine group, (3) the hexone base group, and (4) the creatinine group. As distinct from the ptomaines the leucomaines are of endogenous origin and previously it was considered that their production in the organs and tissues of the body played the chief rôle in autointoxication. Inasmuch as it has been established that most of these compounds are without toxic properties such a view is no longer tenable. Frank P. Underhill.

Leucopenia.—An absolute reduction in the number of leucocytes in the circulating blood below the lowest normal limit is termed leucopenia or hypoleucocytosis. It is the opposite of leucocytosis or hyperleucocytosis. The low normal limit is usually given as 5,000 per cubic millimeter. It is rather seldom in any condition that the leucocytes fall very much below 3,000 per cubic millimeter. Koblanck reports a remarkable case of leucopenia in an epileptic man of twenty-five years of age. In a careful examination of twenty stained cover-glass preparations, he found only *one* leucocyte. Cabot refers to an unusual case of lymphatic leukemia, in which the white cell count fell from 40,000 to 419 per cubic millimeter in the course of three weeks as the result of the development of an acute sepsis. A leucopenia rarely affects all types of white cell equally, on the contrary, it is not unusual to find a leucopenia associated with a relative increase in one of the varieties. Leucopenia may be physiological or pathological.

Physiological leucopenia may occur after prolonged cold baths, short hot baths, and the stimulation of sensory nerves. Some of these effects may be due to a change in the distribution of the leucocytes in the vessels as a result of vasomotor influences. If disease is excluded, the number of leucocytes—especially the polymorphonuclear—may be taken as an index of the patient's nutrition. A low count indicates poor nutrition.

Pathological Leucopenia.—It is rather difficult to separate leucopenia and a simple absence of leucocytosis. The fact that some of the important infectious diseases show an absence of leucocytosis is of great aid in diagnosis. The following diseases are included in this list: Typhoid fever, tuberculosis, measles, German measles, mumps, influenza, glanders, and acute poliomyelitis (see article on *Leucocytosis*). If, in the course of these diseases, a leucocytosis develops, it points to the presence of a new factor, generally some pyogenic complication such as phlebitis or perforation in typhoid fever or the advent of mixed infection in tuberculosis.

A leucopenia may result from diminished activity of the bone marrow following a lowering in the demand made upon it. Such a condition would occur in malnutrition and starvation. The faster Lucci showed a decrease in his leucocytes from 14,530 to 861 per cubic millimeter after a seven days' fast. This number increased to 1,530 on the eighth day and remained at about this figure during the remaining twenty-two days of the fast.

In very severe infections the number of the white cells is frequently diminished. This is probably due to

injury of the bone marrow so that it is unable to functionate properly. In chlorosis, pernicious anemia, and some severe cases of secondary anemia a like effect may be produced. The reduction of white cells after the application of radium and the *x*-rays is also the effect of injury, first to the circulating blood and then to the spleen and bone marrow.

Various investigators have produced a decrease in the number of leucocytes by the administration of various substances hypodermically. Bohland found that it followed the injection of ergot, sulphonal, tannic acid, camphoric acid, atropine, agaricin, and picrotoxin. Delezene injected various anticoagulant substances, peptone, diastase, and eel serum, with a resulting marked leucopenia. James Rae Arneill.

Revised by Ralph G. Stillman.

Leucorrhea.—This term furnishes another illustration of the very common error, in medical terminology, of confusing a symptom with the condition of which it forms but a part or a phenomenon. Current use, especially after the lapse of a long period of time, so fixes such errors that it is almost a hopeless task to make the correction which is necessary or at least desirable.

The term which is in common use as the synonym of leucorrhea is "whites," which is sufficiently expressive, for leucorrhea etymologically means a white discharge or flow. But there may be white discharges from various parts of the body, especially from mucous membranes; moreover the color of the leucorrheal discharge is not always white, hence the correctness of the term is not at once evident.

The white discharge or flow which is to be considered proceeds from the mucous membrane of the female genital organs, and in common language almost any discharge flowing from the vagina is referred to as leucorrhea. In the majority of instances it is a glandular secretion, and may be discharged from the glands or epithelium of the vagina or uterus. Its color is by no means always white; it may be brown, green, or yellow when purulent, or red when mixed with blood.

It is composed of serum mingled with epithelial cells, with leucocytes, or with blood or mucous corpuscles, according as its color is brown, white, red, or yellow. Its reaction is acid when it is derived from the vagina, and alkaline if derived principally from the interior of the uterus. It may be bland and unirritating, or viscid, acrid, and excoriating.

It is odorless, if discharged very soon after it is secreted, but is more or less offensive if retained very long within the vagina or uterus. Its consistency is that of water, pus, or mucus, with a specific gravity which varies according to the admixture and weight of the various substances which may be combined with the watery basis. It may be thin and watery, thick like the white of egg, or semi-fluid like the pus from an abscess. A discharge of this character may always be considered abnormal, for the genital mucous membrane in health secretes only so much material as may be necessary for its lubrication; hence the more abundant the discharge or the more complex its character, the more it is an evidence of disease.

The quantity or volume of a leucorrheal discharge varies within wide limits. There may be only an almost inappreciable moisture, which, however, may be annoying on account of its irritating action and the staining and soiling of the garments, or there may be a continuous dripping which requires the use of a napkin.

Its effects and consequences vary greatly in different cases, and are not always commensurate with its quantity or even with its physical qualities. It may cause no great disturbance aside from an unpleasant sense of moisture or it may produce the most profound irritation and corrosion, the epithelium of the vagina and vaginal portion of the cervix being macerated, with accompanying erosion and ulceration, and the skin being chafed, inflamed, or necrosed. The local condition may react unfavorably upon the system in general.

The debility produced by the constant abstraction of fluid from the blood, by the intense itching which is almost intolerable by day and worse by night, and by the absorption of more or less toxic material, shows the possible deleteriousness of a condition which under ordinary circumstances is hardly thought worthy the dignity of serious notice.

Pain is a not infrequent accompaniment. Under the ordinary conditions in which there is merely a milky or watery discharge there is no pain, but when the discharge is associated with acute inflammatory conditions very severe pain may be present. This symptom is quite distinct from the mere annoyance of the discharge or the irritation and itching which are caused by the chafing and excoriation of the skin. The other well-known symptoms of inflammatory conditions, swelling, heat, and redness, are, of course, present in greater or lesser degree.

There is probably no morbid condition to which the female genitals are susceptible which is of such frequent occurrence, in some form or other, as the leucorrheal discharge. It may be present in infants, in young children, in young adults, in mature women, and in the aged. It is probable that it is for this reason that some gynecologists of wide experience have insisted that it is not necessarily an abnormality. With this sentiment I cannot agree, for, as already stated, the function of the mucous membrane is not to secrete a discharge which shall be appreciable and annoying, and if such a discharge is secreted the conclusion is only a logical one that it is due to some violation or fault of the natural law.

The grouping or classification of the various conditions in which leucorrhea is present is not an easy matter. The field is so large that it is difficult to treat it with satisfactory comprehensiveness. It must always be remembered that leucorrhea in itself is a symptom and not a disease, and as it always has a cause we are hardly justified in applying to it that unfortunate term *idiopathic*, which has always seemed to me a subterfuge for ignorance.

We can differentiate it in diseases which are acute and in those which are chronic. It is also a symptom in diseases which appertain almost exclusively to the genital organs, and in those which are general or constitutional. Of the diseases of the genital organs the acute infectious ones are the most common, especially the venereal diseases.

Syphilis is essentially a chronic disease, and leucorrhea when occurring as one of its symptoms may be considered under this category.

Chancroid is an acute venereal disease but is not so frequent in women as in men. The ulcer or sore which is its essential characteristic may be located upon the opening of one or both of the vulvovaginal glands or upon any portion of the mucous membrane of the vagina or the portio vaginalis of the neck of the uterus. Inflammation attends the development of this disease and is accompanied by a leucorrheal discharge which is at first purulent, then mucopurulent, sometimes streaked with blood, or merely mucous and viscid. It is more abundant in young than in mature women and seldom produces constitutional symptoms that are of importance.

The treatment consists in the use of astringent applications to the sore or ulcer, astringent vaginal douches, and a vaginal tampon of cotton wool properly medicated. I am accustomed to apply the solid nitrate of silver daily to the sore, followed by a vaginal douche of at least two quarts of very hot water and an injection of one or two ounces of peroxide of hydrogen, then applying a tampon moistened with a two-per-cent. mixture of ichthyol in glycerin.

By far the most common form of infectious disease of the genital organs giving rise to a leucorrheal discharge is *gonorrhea*. The part which is primarily infected may be the vulvovaginal glands or the mucous membrane of the vagina or vaginal portion of the cervix. The original focus of infection usually enlarges, whether in circles or in straight lines we do not know, attacking one portion of mucous membrane after another, until the entire mucous tract from the vulva to the junction of the mucous membrane of the Fallopian tubes with the peritoneum may be involved. The process may even extend to the peritoneum, and indeed we know that this actually occurs in not a few instances. After the period of congestion in such cases comes the period of discharge, and the vagina is constantly bathed with a fluid which is purulent, tinged with blood, mucopurulent, and then mucoid. It is always intensely infective, the period during which it continues being variable, depending upon the age and physical condition of the patient, the treatment which is given, etc. In young women the discharge is more abundant, more virulent, and more persistent than in those who are mature or aged. The tissues involved are extremely sensitive, and pain and swelling are pronounced and decisive.

During the first few days of the disease the tissues are so swollen and tender that little can be done except to keep the skin of the external genitals as clean as possible. A simple method of accomplishing this is to place a pad of absorbent cotton over the genitals, holding it in position by means of a snugly fitting napkin. It may be necessary to replace pad and napkin by clean ones five or six times daily. When the swelling and sensitiveness have somewhat subsided the patient should be placed in the Sims position, a large Sims speculum being introduced, and the secretion removed from the entire mucous surface with absorbent cotton and with the utmost care and gentleness. The entire surface may then be carefully swabbed with a strong solution of nitrate of silver (two drams to the ounce of water) and the vagina tamponed with cotton wool saturated with a two-percent. mixture of ichthyol in glycerin. This treatment must be repeated daily until the discharge has diminished, the intervals of application being then lengthened gradually, but it must not be discontinued until all discharge has ceased. It is absolutely imperative that this treatment be carried out regularly and systematically, as it may prevent the extension of the disease to the bladder, Fallopian tubes, and ovaries. I have also found it useful to administer internally an antiseptic, such as the salicylate or the benzoate of sodium, which may be given in ten-grain doses in an aromatic water before meals. The consequences of this disease may be so serious that too much care cannot be taken in giving it the most intelligent treatment which is possible.

The discharge which proceeds from the interior of the uterus cannot be treated so early as that which proceeds from the vagina, but as soon as the acute inflammation of the uterus has subsided it should be carefully removed from the canal with a cotton-wrapped probe or sound and the nitrate-of-silver solution then applied over the entire surface of the uterine mucous membrane. It must be remembered that violent treatment of the uterus during the acute period of inflammation will not only give intense pain but may excite metritis of a severe type, or even peritonitis. If the uterine discharge cannot be readily removed in the manner indicated it is better to wait a few days and then to scrape the entire endometrium with a dull curette.

The leucorrhea which follows *abortion* is quite similar in its characteristics to that of gonorrhea, indeed it is often of gonorrheal origin. The discharge in such cases usually proceeds from the uterine canal and is purulent or mucopurulent in character. It may be thick and tenacious and is sometimes removed with difficulty. It is better that it be not removed at all than that violence be used in attempting to remove it. It proceeds from the entire surface of the endometrium and may come also from the mucous surface of the Fallopian tubes. The latter occurrence is rare, for the uterine ostium of the tubes in these cases is usually swollen and impervious and the material which is secreted is retained, forming a tumor of greater or smaller dimensions. The period during which an abundant discharge from the uterus occurs in this disease, the acute period, usually extends over one or two weeks. It then subsides under proper treatment or it may become chronic and continue indefinitely. The applications of the nitrate-of-silver solution and the cotton-wool tamponnade should be used for this disease in the same manner as for gonorrhea, but it should be remembered of course that the disease is not always of gonorrheal origin. If gonorrhea is not present the discharge is neither so infective nor so virulent as that which accompanies the specific affection.

A leucorrheal discharge is often a sequel of *parturition*, differing decidedly from the ordinary lochial discharge. It implies that inflammation has followed the parturient process, which may be the awakening of some latent focus of disease in some portion of the mucous tract of the genital apparatus. This discharge may be purulent or mucopurulent, and more or less profuse and irritating, and under ordinary conditions continues for from one to three or four weeks. It is unwise to disregard it, and it is usually treated effectively by morning and evening vaginal douches of hot water, which is made sufficiently astringent by the addition of alum or tannic acid, in the proportion of a tablespoonful to the quart of water.

During *pregnancy* a leucorrheal discharge from the vagina is not unusual, resulting from the congested condition of the vessels. It is often very annoying from the irritation to the skin which it causes and the constant soiling of the clothing. It usually yields to the systematic use of astringent vaginal douches.

A discharge of a purulent character frequently follows *surgical operations* upon the genital organs, especially in those cases in which primary union has not taken place. The treatment should consist further in the use of astringent vaginal douches twice daily, and a snugly fitting vulvar pad of absorbent cotton should constantly be worn.

Injuries to the genital organs are usually followed by an abundant discharge from the vagina, constituting the customary discharge of an inflamed mucous membrane. Such injuries may be due to blows or thrusts with sticks or other substances, falls astride a chair or fence, brutality, rape, etc. They may be attended with great pain and swelling of the affected tissues. The chief considerations in their treatment are rest and cleanliness, the secretions being removed from the vagina with care and thoroughness at least once a day, and astringent vaginal douches being taken twice daily. The principle of treatment is that which applies to wounds in general, rest being an important factor in such treatment. Walking, working, or anything which causes motion of the diseased tissues interferes with the recuperative forces of nature.

Excessive coitus and *masturbation* are frequent causes of leucorrhea. The repeated congestions of the mucous membrane in such cases furnish sufficient explanation of its mode of origin. The discharge is usually white or milky, and is often profuse, and irritating to the skin. It is the more troublesome as the individual is careless as to the conditions which provoke the discharge. The treatment is such as has already been indicated.

In little children leucorrhea may be due to the irritation of *worms*. Either the large round worms (lumbricoids), or the small seat or thread worms (ascarides) will produce it. The discharge is frequently profuse and annoying, irritating and excoriat-

ing the skin, and making the child's life miserable. It is usually brown in color and viscid in consistency. I have found it a most difficult condition to cure until the worms are discovered and destroyed. It will usually be necessary to examine the patient under anesthesia, dilating the entrance of the vagina with the finger if necessary. The vagina should be irrigated with a hot solution of boric or salicylic acid (one dram to the quart of water), and the irrigation repeated daily until all congestion of the vaginal mucous membrane has disappeared. Of course a suitable cathartic must be given to dislodge the parasites from the rectum, and the ordinary rules of hygiene must be carefully regarded.

The leucorrhea which accompanies *dysmenorrhea* is often prolonged and tedious. If it is due to a deformed and immature condition of the uterus it is usually remedied by pregnancy, but pregnancy does not often occur when such a condition of the uterus obtains. A surgical operation will sometimes bring relief, but is not an infallible remedy.

The leucorrhea which occurs in aged women, technically known as *senile vaginitis*, is essentially a symptom of a chronic disease. It sometimes proceeds from the vagina alone, and sometimes from the uterus as well. The discharge is usually a dirty, watery, acrid fluid which irritates the mucous membrane and skin, causing the most intense itching, and the rubbing and scratching to which it gives rise produce the most annoying and even painful results. The tissues become swollen and excoriated, and the patient is deprived of peace and comfort by day and by night. The general health is often as greatly deranged by this form of leucorrhea as by any in the entire category. Nevertheless, I have seldom seen a case in which great relief could not be obtained by careful and persistent treatment. An examination must first be made, and if the source of trouble is found to be within the uterus, the endometrium must be thoroughly curetted. The uterus and vagina must be irrigated with an astringent solution (alum or tannic acid) and the vagina tamponed with cotton wool saturated with a mixture of subnitrate of bismuth and glycerin, enough of the former being added to the latter to make a rather thick paste. This paste must also be smeared over the swollen and inflamed external genitals. The treatment should be repeated every day or every second day until a cure has resulted.

The leucorrhea which is an accompaniment of *malignant disease* of the uterus and vagina is susceptible only of palliative treatment. The discharge is profuse, watery, and very offensive. Curettage, irrigation with strong astringent solutions, and tamponade of the vagina will give a certain degree of relief, but the result will be uniform and uniformly fatal unless extirpation of the diseased organ is practised at a very early period.

We now come to the subject of leucorrhea which occurs as a secondary phenomenon in the course of some constitutional or general disturbance. The list of diseases which may have this symptom is a long one, and the characteristics of the discharge are such as to make this the typical form of leucorrhea as it is ordinarily considered. Foremost among these diseases may be mentioned those in which there is a chronic condition of malnutrition, the leucorrheal discharge being one of the elements of its expression. The tissues are relaxed, the tension of the blood current is low, there are stasis of the venous circulation and transudation of serum and corpuscles in the vagina where the vessels are numerous and the resistance is slight. Diseases which at once suggest themselves as possessed of these conditions are tuberculosis, malaria, anemia, chronic rheumatism, and the various forms of chronic, slowly progressing nervous disease. Those who suffer from excessive obesity, with its accompanying impairment of circulation may also be placed in this category.

Another class of cases includes individuals who suffer with the infectious diseases, typhoid fever, scarlet fever, diphtheria, and measles. In such cases there is congestion of the genital organs, and the discharge sometimes continues long after all other symptoms of the disease have disappeared. Especially is this the case with children, and often, in addition to the leucorrhea, an impression is produced upon the structure of the uterus—whether as the result of toxic influence or of interference with the circulation, is not known—which permanently affects its development and lays the foundation for future trouble which may prove of a serious nature.

Yet another class of cases includes those in which the causative influence is transient in character but may recur an indefinite number of times. Illustrations of such a cause are climatic variations, especially great heat and dampness, fatigue and emotion, particularly the extremes of emotion which are experienced by the hysterical and by those who are passing through the menopause. In all these varying forms of disease, if leucorrhea is present as a symptom (and it frequently is present), there is one characteristic discharge which is usually observed, viz., the white watery variety, more or less abundant, more or less irritating, and more or less persistent.

The treatment for leucorrhea in the three classes of cases last mentioned must consist primarily in the treatment of the cause. With such diseases as tuberculosis, syphilis, anemia, etc., the local symptom is not usually removed by any form of local application or manipulation, however judicious or skilful, until the underlying cause is either removed or greatly ameliorated. If the discharge is due to an infectious general disease, such as one of the specific fevers, it will tend to self-limitation, but it may continue a long time after the fever has disappeared, and permanent lesions of the sexual organs, with leucorrhea as one of their persistent accompaniments, are frequently attributable to such a cause. If the discharge is due to emotional causes, hysteria, etc., the removal of the cause is almost a hopeless task, for the changing of one's nature and characteristics is not a common occurrence. It is certainly proper in all these various cases to impress upon the patient the necessity for the observance of a most careful personal hygiene, whether any medicinal or surgical treatment is employed or not. The constant use of the vulvar pad of absorbent cotton, the employment, morning and evening, of the vaginal douche with a hot astringent solution, and rigid attention to the skin, the bowels, the diet, the sleep, and the mode of occupation, may be more serviceable than any amount of professional attention.

The prognosis of this condition depends upon many factors. It is frequently entirely curable, recurring if the original cause is repeated, or it may be of a character which will preclude radically successful treatment, as in the case of malignant disease. Its importance is sufficiently great to warrant careful study on the part of every physician who may be called upon to treat the disorders of the female sexual apparatus.

ANDREW F. CURRIER.

Leukemia.—*Synonym.*—Leucocythemia.

Definition.—Leukemia is a disease of unknown etiology, dependent upon pathological changes in the blood-forming tissues, and characterized clinically by an extraordinary increase in the white cells of the circulating blood. The definitive condition of the disease lies in the changes in the blood-forming tissues. Under the influence of treatment, intercurrent disease, or spontaneous remissions the increase in the white cells of the circulating blood, usually distinctive of the disease, may temporarily disappear.

HISTORICAL NOTE.—The first recorded observation of this remarkably interesting disease is credited to the English physician Hughes Bennett, who in October,

1845, published an account of an autopsy upon the body of a man who died with a much enlarged liver and spleen, and whose blood was filled with corpuscles which Bennett described as exactly resembling pus. A few months later the great German pathologist Virchow independently recorded a similar observation, but coupled with his observation the conclusion that the remarkable cells seen in the blood were not pus but the white corpuscles of the blood, present in many times their normal number. The credit of prior observation, therefore, rests with Bennett, but to Virchow undoubtedly belongs the honor of correct interpretation of the blood changes. Virchow also followed up his original observation by a series of papers upon the subject and in the first volume of his Archives published an account of a case differing from all those previously described in that a general enlargement of the lymph-nodes of the body was accompanied by an increase of the small white cells of the blood, instead of the large. To this affection he gave the name of lymphatic leukemia, while the earlier described disease was termed splenic leukemia, a distinction which in modified form prevails to the present time.

The first monograph upon the subject of leukemia was that of Mosler published in 1872. Despite the eager observation and much hard study of the years that had intervened since the first reports, Mosler recognized that his work constituted only the beginning of a knowledge of the subject, and unburdened his feelings in these prophetic words: "How much remains to be done, how little the experience of any one observer can suffice is made evident by progressive study. After more than twenty-five years of ceaseless labor one is astonished to see how far we still are from the goal which advancing knowledge in this field seeks to attain." More than fifty years of constant study has not sufficed to bring us to the goal of a complete understanding of the disease, and yet much has been added to our knowledge. The introduction of tinctorial methods of studying the blood and blood-forming tissues by Ehrlich has enormously extended our information as to the types of blood cells and their seats of origin. The recognition of acute leukemia by Ebstein, the description of its blood changes by Fraenkel, the demonstration of the relationship of changes in the bone marrow to the changes in the circulating blood by Neumann, and more recently the intensive study of the changes in the blood-forming tissues have very considerably enlarged the bounds of our knowledge of the pathology and pathogenesis of the disease. The search for the cause of these tissue changes and the profound modifications of the blood which regularly accompany them has thus far been in vain. Undoubtedly until that search is successful, our knowledge of the phenomena of leukemia must remain imperfect and unsatisfactory. We must be content to describe and classify the variations in tissue changes and in the blood pictures accompanying them as they present themselves in clinical work. Along both these lines an enormous amount of work has been done of recent years with considerable modification of the prevailing views as to the tissues of the body affected in these processes and the associated changes in the blood. For an adequate understanding of the subject we must, therefore, summarize our present knowledge of these subjects.

Histogenesis of Leukemia.—In the early studies, two forms were distinguished, lienal and lymphatic, according as the spleen or the lymph-nodes were found hypertrophied. In the lienal form Virchow established the presence of larger types of blood cells in contrast to the small lymphocytes found in the lymphatic type. At the outset Virchow based his classification upon histogenetic changes. Later investigations demonstrated the leading rôle of the bone-marrow as a blood-forming tissue, and as in both forms of leukemia thus far recognized the bone-marrow presented material changes, the primary origin of all leukemia was referred to this tissue. Neumann distinguished two types of leukemia: (1 with lymphatic changes in the bone-marrow, in great part corresponding to the present type of lymphatic leukemia, and (2) with pyoid changes in the bone-marrow, the analogue of lienal leukemia.

The studies of blood-morphology inaugurated by Ehrlich, and of the finer tissue changes, in time led to another conception, the duality of leukemia, and the cardinal importance of the bone-marrow for the origin of all leukemias was set aside. In many instances the non-pyoid, gray-red, and apparently lymphatic marrow was proven on histological examination to be composed wholly of myeloid cells, and in some cases the bone-marrow was found to be but slightly or not at all involved. (Naegeli.)

Investigations of the presence of the leucocyte-forming tissues in man under embryonal, normal, and pathological conditions, which were necessary to the elucidation of this question, brought forth evidence that the two systems are separate and distinct, and that transitions from one to the other do not occur.

These investigations gave the following results:

1. Myeloid tissue, in the adult human organism, is present only in bone-marrow, but under the influence of infectious processes, toxemia, or anemia it may readily appear in the spleen, lymph-nodes and perivascular tissues in many parts of the organism (myeloid metaplasia). In the vessel walls or their adjacent tissues definite cells must possess the capacity for this transformation. In the embryo one sees in certain early stages, especially in the neighborhood of vessels and often in considerable territories myeloid tissue, particularly in the liver and spleen, while cells of the character of small lymphocytes are almost entirely absent.

2. Lymphatic tissue on the other hand is found widely distributed in the adult human organism, not only in the lymph-nodes and the spleen, but also in the lymphatic tissue of the mucous membranes, and in small foci in various organs. In bone-marrow, apart from some cells in the adventitia, only in very recent times has the presence of lymphatic tissue, sharply distinguished from the myeloid parenchyma, been demonstrated. In the embryo lymphatic tissue appears relatively late and has not the functional activity seen in later life.

That the leukemias therefore comprise hypertrophy either of the myeloid or lymphatic tissues is now generally accepted. Investigation has failed to demonstrate transitions from one system to the other, in the sense in which transformation of one type of leukemia into another was formerly described.

Myeloid leukemia is therefore a system affection of the myeloid tissues, an increase either of ripe cells (myelocytes and leucocytes in addition to erythroblasts), or of unripe cells, the myeloblasts. In both cases, which are united by numerous intervening and transition forms, the multiplication occurs in very definite situations, that is, in places in which in the embryonal period myeloid tissue formation occurs. Lymphatic leukemia is, on the other hand, a system affection of the lymphatic tissues (Ehrlich and Pinkus), again corresponding to a multiplication of normally present lymphatic cell complexes in lymph-nodes, the Malpighian bodies of the spleen, the follicles of the mucous membranes, etc. The hyperplasia is here also found in definite situations, differing however from those of the first mentioned type of leukemia.

Types of Blood Cells and Their Origin.—Inasmuch as we are ordinarily dependent upon the blood changes for the clinical evidence of the leukemias, a knowledge of the varieties of blood cells and their genesis is essential to an understanding of the affections grouped under this title.

Leucocytes.—In view of their importance the leucocytes are first considered. From the earliest studies of the blood two chief varieties of leucocytes have been recognized, mononuclear and polynuclear. The elaborate methods of staining and studying the blood introduced by Ehrlich have resulted in the subdivision of each of these chief varieties into a number of subsidiary types.

Numbers.—The average number of leucocytes in health is about 7,000 per cubic millimeter. Physiological variations may be within the limits of 5,000 to 10,000 per cubic millimeter. The normal ratio of white cells to red may therefore be anywhere from 1 to 1,000 to 1 to 500.

A. Mononuclear Forms.—Cells with one nucleus and varying amounts of non-granular, basophilic protoplasm, when stained by Ehrlich's triacid stain. With other stains, such as Romanowsky's or Leishman's, very fine granules of varying tints may be demonstrated. Ordinarily, however, the protoplasm of the mononuclear types appears non-granular.

1. *Lymphocytes.*—(*a*) *Small lymphocytes,* cells about the size of erythrocytes, having a relatively large, round, centrally placed nucleus with a narrow protoplasmic ring about it. These lymphocytes possess but slight power of ameboid movement. The protoplasm stains with all dyes, but has especial affinity for basic stains, particularly methylene blue. With this dye the cell body stains deeper than the nucleus and appears to consist of a light-blue ground substance in which are imbedded many fine basophilic granules. Such small lymphocytes normally constitute about twenty-five per cent. of the white cells.

(*b*) *Large Lymphocytes.*—These cells are two or three times the size of the small lymphocytes, are very few in number, and have the same general characters as the small lymphocytes.

(*c*) *Large Mononuclear Leucocytes.*—These types are two or three times the size of the small lymphocytes, yet are usually regarded as distinct from the large lymphocytes, in that the nucleus is eccentrically placed and the protoplasm more abundant. Some observers regard them merely as varieties of the large lymphocytes and consider differentiation impossible. Among the large mononuclear leucocytes are found some with indented or horseshoe-shaped nuclei which are classified as transitional types. In normal blood the large mononuclears constitute about five per cent. of the white cells.

B. Polynuclear Forms.—Large (eleven microns) cells with a deeply indented or polymorphous nucleus, or several small nuclei, and a very granular protoplasm. By the staining reactions of these granules the polynuclear cells may be further classified into:

(*a*) *Neutrophile polynuclears,* normally constituting sixty to seventy per cent. of all white cells, usually classified simply as polynuclears, characterized by the fact that their abundant granules stain best when both acid and basic dyes are used.

(*b*) *Eosinophile* cells are characterized by their large size and the high refractile index of their granules which stain deeply with acid dyes. The normal percentage of eosinophiles varies from 0.5 to 4.

(*c*) *Basophile Polynuclears.—Mast Cells.*—These cells closely resemble the eosinophiles, except that the large granules stain only with basic dyes. They constitute normally but one per cent. of the leucocytes.

C. Leucocytes not Found in Normal Circulating Blood.—1. *Myelocytes.*—These are mononuclear forms of varying size, some of them very large, some small, with definitely staining granules in their cytoplasm.

(*a*) *Neutrophile myelocytes,* large cells, with neutrophile granules, and large, oval, faintly staining nuclei. These cells appear abundantly in the blood only in the myelogenous leukemia. In small numbers they have been observed in tumors involving bone-marrow, in other severe anemias, and in some acute infections.

(*b*) *Eosinophile myelocytes,* like the preceding, except that the granules stain with acid stains. They are relatively rare, and are met with in but few conditions other than leukemia.

(*c*) *Basophile myelocytes* and large mononuclear cells with basophile granules, seen only in long-standing cases of myelogenous leukemia.

2. *Rare and Irregular Types of Cells.* In the leukemias, in pernicious and other severe anemias there appear types of leucocytes which cannot be satisfactorily assigned to any recognized category, and regarding whose assignment different observers fail to agree. Such cells are not sufficiently numerous to be important.

Source of Origin of White Cells.—While if the origin of blood cells is traced far enough backward, we find that all cells, lymphocytes, polynuclears, and erythrocytes are derived from one original type-cell, the colorless, mononuclear, non-granular cell in the adult mammal, these principal groups of cells maintain separate and largely independent existence. Lymphocytes are developed in the lymphatic tissues above enumerated, especially the lymph-nodes and spleen, but it is important in this connection to emphasize the fact that there is lymphatic tissue in the bone-marrow and that large numbers of lymphocytes are normally present in this tissue. Longcope found twenty-two to twenty-three per cent. in the marrow, and Pappenheim and Price Jones have confirmed this finding. The main seat of lymphocytic formation is, however, the lymph-nodes and spleen. Here in a manner analogous to the origin of myelocytes in bone-marrow they are formed from large basophilic, mononuclear cells, which do not ordinarily appear in the blood, except as large lymphocytes in children, but under pathological conditions, such as lymphatic leukemia, they may appear in great numbers, especially in the acute form of the disease. In their later stages the nuclei of these cells become lobulated or undergo fragmentation without their protoplasm losing its basophilic, non-granular character.

In like manner the bone-marrow is the almost exclusive source of the polynuclear leucocytes and myelocytes, although, as already pointed out, myeloid tissue may be found in various parts of the body, even the spleen, and lymph-nodes. In the bone-marrow the myelocytes take origin from primary non-granular, basophilic, mononuclears. Here the myelocytes develop their granules, the nucleus undergoes modification into the lobulated type, and the fully developed cells enter the blood as polynuclear leucocytes. A few immature cells, still non-granular, basophilic and mononuclear, enter the blood and maturing there become polynuclears. The cells which have begun to mature in the marrow normally complete that evolution there so that myelocytes do not appear in normal blood. Mature polynuclear cells do, however, under chemotactic irritation (acute infections, etc.) enter the blood in increased numbers at times, giving rise to a leucocytosis. The loss of the polynuclears in the marrow is compensated by the formation of new myelocytes and their development into the more mature types. Under the pathologic conditions of myelogenous leukemia not only the polynuclears but the myelocytes themselves pass into the circulating blood in enormous numbers.

The Red Cells or Erythrocytes.—In fetal life the first red cells are produced by modification of mesoblast cells in the vascular area surrounding the embryo. Later in the fetal period the liver, the lymph-nodes, and possibly the spleen participate in the formation of red cells. Finally the bone-marrow takes over this function and in postnatal life becomes the only source of erythrocytes. The first red cells are large nucleated forms, megaloblasts, with or without hemoglobin. The megaloblasts give rise to smaller nucleated forms, normoblasts, which in turn by disintegration and absorption of the nucleus become the red cells of the circulating blood. These processes are normally carried

out in the blood-forming tissues, in adult life the bone-marrow only, and nucleated forms are rarely found in the circulating blood. Under pathological conditions, such as prevail in pernicious anemia or the leukemias, proliferation of red cells may again take place in the liver, spleen, and even the peripheral circulation. A certain number of cells of the fetal type remain in the bone-marrow in later life. The megaloblast and its unpigmented progenitor remain as non-circulating elements, and under abnormal conditions may proliferate to such an extent that megaloblasts, megalocytes, and normoblasts appear in the circulating blood. While these processes are best illustrated in pernicious anemia, they are frequently exemplified in advanced cases of leukemia and in other severe types of anemia. The normal red cell count in the human adult ranges between 5,000,000 and 6,000,000 per cubic millimeter. Although there is a steady loss of red cells through their destruction in the liver and possibly in other tissues, this number is kept constant by the influx of new cells from the bone-marrow. Under ordinary conditions these new cells are fully matured erythrocytes with normal characters. When the stimulation of the bone-marrow becomes excessive, immature or imperfectly developed cells may be thrown into the circulation and we may then find in the blood nucleated red cells, either large or small, and great variations in form, size, and staining of the non-nucleated erythrocytes.

Accumulating observations broaden the classification of the leukemias. We now describe:

1. Myelogenous Leukemia; *a.* acute, *b.* chronic.
2. Lymphatic Leukemia; *a.* acute, *b.* chronic.
3. Chloremia; *a.* myleogenous, *b.* lymphatic.

Myelogenous Leukemia.

Synonyms: Spleno-myelogenous or myelocytic leukemia, myelemia, myelosis.

Occurrence.—Familiar in hospital work leukemia in any form is still a comparatively rare disease. In 141,777 consecutive medical cases Bramwell found but five of leukemia. In the University Hospital, Ann Arbor, Mich., Dock reported eleven cases of leukemia in 10,000 admissions. In the Presbyterian Hospital, New York City, in the last eight years among 20,721 admissions, there have been recorded thirty cases of leukemia. It must also be remembered that rare conditions tend to be referred to the hospitals. In private practice one may go many years without encountering a case.

The disease occurs commonly in middle life, and rarely indeed in infancy, yet it cannot be said that any period of life is distinctly exempt. Men are more often afflicted than women.

Predisposing Factors.—Syphilis, malaria, and abdominal (splenic?) injuries have been given importance in this relation, but there is no convincing evidence that any of these influences is ordinarily concerned.

Etiology.—We are at present quite in the dark as to the cause of the disease. Every effort to demonstrate a specific infectious agent has thus far failed.

Clinical Description.—The onset. The inception of the disease is always gradual, insidious. It may be marked by progressive weakness, loss of flesh, loss of appetite, a slight fever, possibly cough, so that tuberculosis is suspected. In other cases the early symptoms are produced by the splenic tumor, attention being called to the increasing size of the abdomen, the oppression in the epigastrium or left side, definite pains in the splenic region, or the presence of a firm tumor in the side. In still other cases the progressive anemia and the tendency to bleed from the gums or other mucous membranes may be the first symptoms. In the male priapism has been repeatedly marked in the onset of this disease.

Once leukemia is established the clinical course varies greatly. Either of the groups of symptoms noted at the onset may prevail throughout the course or these may be combined in many different ways. Usually the weakness and emaciation are progressive, yet in the more chronic types of the disease the strength and well-being of the patient may be preserved even for several years. In a case recently observed the man had continued his work as the driver of a beer wagon for many months after the onset of the disease. When he entered the hospital his spleen filled the entire left half of the abdomen and his leucocytes numbered nearly 300,000, yet after a period of treatment he left the hospital much improved and resumed his laborious occupation! Usually exhaustion is marked and hard work impossible.

Digestive disturbances, loss of appetite, nausea, and vomiting, possibly produced by pressure of the enormous spleen, and intractable diarrhea are common; or the tumor causes much discomfort and pain. The hemorrhagic tendency may be marked and bleeding from the nose, the gums, stomach, bladder, or rectum, or hemorrhages into the skin may suggest purpura. In the late stages of the disease fever of varying degree is frequently seen.

Complications may develop, influenza, pneumonia, secondary infections, sometimes attended by remarkable reductions in the leucocyte count and modification of the characteristic blood picture. Finally the patient succumbs to exhaustion, an increasing anemia with terminal anasarca, severe hemorrhage from some of the mucous membranes, the stomach for example, or hemorrhage into the brain, or to some of the complications.

The duration of the chronic type varies from one to four years. Instances of recovery have been recorded but with more exact criteria of diagnosis every such report is now regarded with suspicion. There is no question that the course of the disease may be stayed by appropriate treatment, but there is no evidence that in these cases the disease is really cured. The inevitable outcome may be delayed, but we are not yet justified in giving anything but an unfavorable prognosis.

Special Symptoms.—*The Spleen.*—Enormous enlargement of the spleen is seen more frequently in myelogenous leukemia than in any other disease. As already stated the presence of the splenic tumor or the symptoms produced by its enlargement may be the earliest symptom of the leukemia. The spleen may fill the entire left half of the abdomen or even extend beyond the umbilicus or downward into the pelvis. As a rule the shape of the organ is preserved and the notches on the anterior border readily identify it. The consistency is ordinarily hard, but variation may occur in this regard and Ehrlich has recorded a case in which the enlarged organ was fluctuating. The surface is generally smooth but may be quite rough from numerous infarctions. Occasionally friction sounds due to perisplenitis may be heard on auscultation over it. As emaciation progresses the outline of the enlarged spleen may be clearly seen through the thinned abdominal wall. The tumor may be quite insensitive or distinctly tender. If small, the spleen is usually easily movable, but the larger it becomes the more firmly fixed it is.

While this splenic enlargement is quite constant and commonly striking, instances in which the organ is only slightly affected are not infrequent. Variations in the size of the spleen mark the course of the disease; especially under treatment by the Röntgen rays or benzol marked reductions in the size of the organ may be produced. Large hemorrhages from the stomach

or intestine may also cause recession. These changes, are, however, only temporary in character and progressive enlargement is the rule.

Lymph-nodes.—Enlargement of the subcutaneous lymph-nodes is not characteristic of the myelogenous type of leukemia. Indeed its occurrence is denied by some authors. Late in the disease, however, the lymph-nodes, cervical, axillary, and inguinal, may be readily palpable, but such enlargements never reach the degree common in the lymphatic type of the affection. In rare instances enlargement of the deeper lymph-nodes, especially the mediastinal and bronchial, may be sufficient to produce clinical symptoms. Pressure upon the bronchi may cause respiratory distress and give physical signs of obstruction. Laryngeal paralysis from pressure upon the recurrent nerve, or laryngeal stenosis from pressure upon the larynx itself, and difficulty in swallowing from pressure upon the esophagus, have been recorded.

The Liver.—In advanced cases the liver is regularly enlarged. It may reach the level of the umbilicus or even descend beyond this line. The surface is smooth, the edge hard, and usually insensitive. Jaundice is not an accompaniment. Between the enlarged liver and spleen the abdomen may be almost completely filled.

The Bones.—Especially the sternum and long bones may be sensitive to percussion and occasionally pain in the bones is complained of.

Circulatory Organs.—The heart and blood-vessels are not involved in the early stages of the disease. Late in the course dilation of the heart with corresponding murmurs of insufficiency may be observed, and the heart action becomes progressively more rapid and feeble. In the terminal stages edema of the lower extremities may develop partly as the result of severe anemia and partly from increasing cardiac weakness. Ascites and pleural effusions may be produced in like manner. In such effusions the characteristic cells of the leukemic blood may be found.

Respiratory System.—The respiratory organs usually show no early disturbances, but a diffuse bronchitis may be present. In later stages increasing dyspnea may result from compression due to the high position of the diaphragm caused by the splenic and hepatic enlargement, the pressure of enlarged bronchial and mediastinal lymph-nodes, the anemia and the cardiac weakness. Pleural effusions or ascites may further add to the distress.

Digestive Organs.—Pressure upon the stomach and intestines, as well as the constitutional influence of the disease may result in early loss of appetite and more or less abdominal distress. Nausea and vomiting may occur. In more advanced cases severe and intractable diarrhea is not uncommon. Bleeding from the gums, hematemesis, or intestinal hemorrhage may occur. The ulcerative processes in the mouth or throat so frequently seen in acute types of leukemia are uncommon in the chronic myelogenous type.

Anemia is usually pronounced and progressive, but may be absent for long periods. Pallor of the mucous membranes and skin, and the constitutional effects of the loss of hemoglobin are proportionate to the degree of anemia.

The hemorrhagic tendency varies greatly in different cases and in the stage of the disease. Hemorrhages most often occur from the nose or gums, but may occur from any of the other mucous membranes, especially the stomach or intestines, or into the skin or brain or other organs. Severe hemorrhage may be fatal.

Genitourinary System.—The urine may show no changes, but frequently albumin and casts are present, and a true nephritis may be developed. Hemorrhage may occur from either kidney or bladder.

The frequency of priapism has already been mentioned. It is said to be produced by thrombosis in the corpora cavernosa. In women amenorrhea is common, uterine hemorrhages rare. Leukemic women have given birth to healthy children without aggravation of their symptoms.

An excessive secretion of uric acid has been demonstrated in this, as well as in other types of leukemia. Uric acid concretions may be found in the kidney or bladder. Albuminuria has been observed in a few cases.

Nervous System.—Involvement of the nervous system is usually the result of anemia or hemorrhage. In the absence of hemorrhages there may be no signs of involvement of the nervous system. Hemorrhages into the brain may occur, and apoplexy is one of the well-known modes of termination.

The Eye.—The fundus in usually pale, the veins large, and the arteries small. Minute whitish infiltrations may be observed in the fundus, or distinct hemorrhages may be seen. Swelling and opacity of the optic disc may also occur.

The internal ear may be involved by leukemic infiltrations or hemorrhages with resulting dizziness, ringing in the ears, dulness of hearing, and even deafness. Such symptoms may be transitory. Severe symptoms belong only to the late stages of the disease.

The Skin.—The skin is usually pale, lusterless, and dry. Various eruptions, erythema, acne, and urticaria, have been observed. Leukemic infiltration of the skin is rare in the myelogenous type of the disease, but small leukemic tumors may be found in the skin in rare cases. In the late stages profuse sweating is not uncommon.

Temperature.—The disease may run its course without fever. On the other hand, particularly in advanced cases, remarkable febrile disturbances may be observed, independent of complications. The fever is usually of distinctly remittent type. It may last months or weeks, the temperature ranging from normal to 103° or 104°. Long periods of freedom from fever may intervene between periods of increased temperature.

The Blood.—Color.—In extreme conditions a drop of blood drawn from the ear or finger appears paler or more watery than normal—often in the early stages no difference can be seen by the naked eye. Virchow's descriptive term, "white blood" was drawn from the post-mortem appearances, and in the case which gave rise to it an epistaxis just preceding death had shown apparently normal blood.

Red Cells.—The number of red cells is ordinarily reduced, their hemoglobin content still more so, the color index being thus less than one. Only in the late stages is extreme reduction of the red cells and hemoglobin observed. In like manner the appearance of the red cells at the onset may be normal, later variations in shape, size, and staining of the erythrocytes appear. Nucleated forms, either normoblasts or megaloblasts, are usually to be found, even early in the disease. Occasionally the nucleated cells are numerous.

White Cells.—An enormous increase is usually noted upon the first examination, the total count reaching 200,00 to 500,000; it may be 1,000,000. The relation of white to red cells may be 1:1. On the other hand in rare instances the increase in white cells may be only slight, say 50,000. Under the influence of treatment or complications, great variations in the leucocyte count develop. The number may fall even to normal limits and continue there for months, but in the end the extreme leucocyte increase returns. Usually it is persistent and progressive, the count mounting higher and higher with the progress of the disease.

Differential Count.—More important than the number of white cells is their variation in type. All varieties of white cells found in bone marrow appear in the circulating blood. The polymorphous variation of the leucocytes is more constant than the increase in number, persisting in part at least even when the

total count approaches normal. The exact differentiation of the many types of leucocytes encountered in myelogenous leukemia is a matter of great difficulty. The making of the smear and the manner of staining play no small part in the result. In consequence, considerable differences in the description of types of cells observed and their assignment to definite categories are to be found among the most careful students. It is, therefore, not well to lay too great stress upon the minute details of staining or classification. Gulland and Goodall regard as the essentials of myelogenous leukemia simply: (1) a great increase in all varieties of white cells; (2) a great invasion of myelocytes; the presence of numerous nucleated red cells without necessarily any anemia.

Myelocytes.—All forms, neutrophilic, basophilic, and eosinophilic are to be found, the relative proportions of each varying greatly in different cases. Some are always found, and they may contribute fifty to sixty per cent. of all leucocytes. Together with the polynuclears they constitute so large a proportion of the leucocytes that the other varieties ordinarily appear to be diminished. Accurate calculation shows, however, that all varieties of the white cells are actually increased.

Myeloblasts.—Under this title Naegeli groups certain large lymphocytes with non-granular strongly basophilic protoplasm and a fine-meshed nucleus containing several nucleoli. In moderately developed cases these cells constitute 0.5 to 1 per cent. of the leucocytes, increasing to higher percentages in the later and severer stages of the disease. Other observers find it impracticable to draw such distinctions in the classification of the mononuclear cells.

Of the polynuclear type the neutrophiles are, as a rule, the more abundant, but the eosinophiles are often considerably increased, and in some cases the basophile polynuclears (mast cells) constitute an important part of the total.

The number of cells reported as lymphocytes depends largely upon the acceptance of the myeloblasts as a definite type. Compared with the myelocytes and polynuclear forms they are relatively few in number. As already noted there are usually present in myelogenous leukemia numbers of cells whose classification depends largely upon the individual observer.

In different cases of myelogenous leukemia and in various stages of a single case great variations in the distribution of the many types of leucocytes may be noted. It is quite impossible at the present time to correlate these variations with the course of the disease. It may, however, be noted: (1) Under treatment by arsenic, the Röntgen rays, or benzol the blood picture may be considerably modified toward the normal. Thus the myelocytes may be notably reduced or may even disappear. The mast-cells and eosinophile types are more persistent. (2) Acute infectious processes, such as erysipelas or pneumonia may for a time completely suppress the leukemic blood picture, but the improvement is only temporary, and the leukemic characters reappear with the subsidence of the infection. (3) Naegeli regards as most important the distinction of the myeloblasts and their variation. He finds them ordinarily in small numbers, but states that they increase notably in all acute exacerbations of the leukemic process, and especially in cases unfavorably influenced by Röntgen rays or thorium. Under these circumstances, when the therapeutic process is not carefully controlled by observation of the blood, a rapid increase in the myeloblasts may occur and death shortly follow. In the preagonal stages the myeloblasts may constitute thirty to fifty per cent. of all leucocytes.

Pathological Anatomy.—The body is emaciated, the skin extremely pale, usually there is edema of the lower extremities, and ascites.

The blood is pale and watery. In the heart and great vessels large, soft, greenish-yellow or whitish clots are found. Charcot-Leyden crystals are often demonstrable in the blood of myelogenous leukemia.

Changes in the bone marrow may be widespread, or limited to the sternum, ribs, and long bones. In its most characteristic form the marrow is soft and yellowish, suggesting pus. In other cases it is grayish or brownish red and but little changed in consistency. Microscopically the marrow shows an extraordinary supply of its characteristic cells. The different types of cells, such as eosinophile myelocytes, are massed in groups. Charcot-Leyden crystals may be present in unusual numbers.

The spleen varies greatly in size, but is usually huge, sometimes attaining a weight of eight to ten kilograms (17.5 to 22 pounds). The capsule is thickened and often adherent to adjacent organs. The cut section is deep red; the follicles are indistinct or altogether absent; the connective tissue is increased. Coverglass preparations show numerous cells corresponding to those of the bone-marrow, illustrating the myeloid metaplasia of the spleen first described by Ehrlich. Microscopically the spleen shows the same myeloid transformation, with few or none of the characteristic lymph follicles, and an excessive growth of connective tissue.

The liver is also greatly enlarged, its consistency firm, the surface smooth, the edge sharp. Microscopically the portal capillaries are crowded with myeloid cells and foci of myeloid infiltration may be found throughout the organ, compressing and even destroying the liver cells. In contrast to the findings in lymphatic leukemia the interstitial tissue is little affected and the lymphoma-like infiltrations of the latter condition are not observed.

The lymph-nodes may be slightly enlarged and some appear grayish red or yellow. Microscopically they show simple hyperplasia similar to that observed in the spleen and liver. The follicles may be compressed or disappear under these conditions.

The heart may be dilated, and fatty infiltration of the heart muscle may be found. Small hemorrhages may be seen upon the surface.

The kidneys show no constant changes but foci of myeloid infiltration may appear in the cortex.

The central nervous system may show hemorrhages in various parts, particularly in the brain. The retina and the internal ear may likewise be sites of hemorrhage.

Diagnosis.—The combination of clinical symptoms with the enormous increase of leucocytes and the characteristic differential count, as a rule, renders the diagnosis of the myelogenous leukemia very easy. The blood examination usually settles the question of diagnosis at once. Only the omission of such examination permits confusion with tuberculosis, tumors of the stomach, spleen, or kidneys. The special features of the differential leucocyte count are quite as important as the total number of the white cells. The possibility of error from the changes in the blood picture induced by treatment or the influence of intercurrent infections has already been pointed out. Under these conditions a repetition of the blood examination after a short time should make the diagnosis clear.

It must be remembered that no one type of leucocyte is pathognomonic of myelogenous leukemia. Myelocytes may be found in considerable percentage in the blood (ten to twenty-five per cent.) in rare cases of malignant metastases in the bone-marrow, or even in severe anemias combined with sepsis. In children especially real difficulty may be encountered in determining the diagnosis in some cases. Repeated examinations of the blood and careful consideration of all the facts will ordinarily enable one to reach a correct conclusion.

Metabolism of Chronic Myelogenous Leukemia.—Reference has already been made to the increased

quantity of uric acid found in the urine in this disease, a result of the rapid destruction of the leucocytes. Xanthin bodies are also abundant in the majority of cases. It has been shown that xanthin bodies ingested with the food can be completely worked up, and the failure of xanthin metabolism appears to be an agonal phenomenon. In like manner an increased excretion of phosphoric acid belongs to the final stages of the disease.

R. Bayer has shown that more iron is retained in the spleen in myelogenous leukemia than in health, and the increased iron content of the spleen is demonstrable.

Under the influence of the Röntgen rays a considerable rise in the uric acid excretion occurs, an indication of increased destruction of the hypertrophic myeloid tissue. In favorably influenced cases a period of lessened excretion of uric acid follows and continues as long as there is no recrudescence of the disease, a fact which is interpreted to mean that the rays exercise an inhibiting influence upon the formation of the leucocytes. In some cases this inhibition fails and the increased uric acid excretion persists despite the lowering of the leucocyte count, an unfavorable condition.

Acute Myeloid Leukemia.

Synonyms: Acute myelosis, Acute myeloblast leukemia, Acute myelocythemia.

This disease is very rare. In 1904 Hirschfeld could find records of only six undoubted cases and in 1912 Gulland and Goodall state that not more than a dozen cases have been recorded.

The general clinical picture is the same as that of acute lymphatic leukemia. As in that disease the onset may be very suggestive of an acute infection, or the ulcerative processes in the mouth and throat may be prominent and the hemorrhagic diathesis pronounced, or it may begin insidiously with swelling of the spleen and lymph-nodes, diarrhea, and increasing weakness. The course of the disease is rapid and progressive, gangrenous and hemorrhagic processes dominating the picture. Often in the final stages secondary infections develop and bacteria of many types, streptococci, etc., have been found in the blood.

The duration of the disease varies from a few weeks to one, or at most three months. The diagnosis must rest upon the results of the blood examination. There is a rapid blood destruction with resulting severe anemia, and the appearance of all manner of pathological variations of red cells, including polychromatophilia, basophilic stippling, cells with fragmentary nuclei, and ring-forms. The number of leucocytes at the onset may be low, 20,000 for example, and even in the late stages they rarely attain the number of 200,000. The characteristic feature of the blood picture is preponderance of myeloblasts (Naegeli) and all possible transitional forms between these cells and myelocytes. Pathological findings correspond to those of the chronic myelogenous leukemia, except that gangrenous processes are more frequently found in the mouth and intestines, and hemorrhages in many organs are more common. Treatment must be purely symptomatic and is altogether ineffective.

Chronic Lymphatic Leukemia.

Synonyms: Chronic Lymphadenosis, Chronic Lymphemia, Chronic Lymphocytic Leukemia.

Occurrence.—As already noted chronic lymphatic leukemia was observed very soon after the early observations of the myelogenous type. It is, however, a much rarer disease. It is infrequent also as compared with acute lymphatic leukemia. Cases have been observed at all ages, many more in men than in women.

Etiology.—We have no satisfactory knowledge of the causation of the disease. Importance has at times been given to some preceding local infection, such as hypertrophy or abscess of the tonsil, persistent ulceration of the gums from carious teeth, etc., but no definite relation can be established in the majority of cases. In like manner all efforts to identify definite bacteria as the excitants of the disease have failed. Pyogenic bacteria have often been found in the lymph-nodes but they are regarded as late and accidental invaders. In this relation special emphasis has at times been laid upon the presence of tubercle bacilli, but the consensus of opinion is heavily against any etiological relation of the tubercle bacillus to this disease.

Clinical Description.—In its clinical picture chronic lymphatic leukemia much more closely approximates Hodgkin's disease than chronic myelogenous leukemia, the most characteristic symptoms consisting of chronic progressive hypertrophy of the lymphatic tissues associated with anemia and exhaustion. While for descriptive purposes we separate lymphatic leukemia into acute and chronic types, no decisive line can be drawn between the two and intermediate cases are not infrequent.

The onset of the disease is almost always insidious, increasing hypertrophy of the superficial lymph-nodes, of the tonsils, or the other adenoid tissues of the throat, or of the spleen with resulting abdominal distress, marking the beginning. Less often progressive anemia and hemorrhage from the mucous membranes draw attention to the condition of the blood. In rare instances the development of lymphomatous growths in the skin or the eyelids, or periosteal infiltrations in the region of the temples or the orbit may be first noted. In some cases the constitutional symptoms, progressive weakness, loss of weight, and malaise may be more prominent than the lymphatic hypertrophies.

Lymphatic Apparatus.—Usually all the superficial nodes present a fairly uniform enlargement, but one group or another, the cervical particularly, may be the seat of the earliest and most marked increase. Rarely is the process distinctly limited to one group. The affected nodes are commonly soft, isolated, painless, involving neither the skin nor the surrounding tissues, but in some instances the nodes of any one part are fused into a general mass. The older the process the firmer the nodes become and the larger their size. They do not ulcerate or break down under ordinary conditions. Their size varies greatly from the most moderate enlargement to the size of an egg or an apple. While progressive enlargement is the rule, recession of particular groups or all the nodes may occur, especially under the influence of treatment. In the neck especially the tumors produce marked deformity and may interfere with motion, but it is relatively rare that they attain sufficient size to produce compression of the trachea, esophagus, or great vessels.

The *spleen* is regularly hypertrophied and may be very large, yet rarely attains the size seen in myelogenous leukemia. In many instances the enlargement is very moderate, the spleen extending only one or two centimeters beyond the border of the ribs. The organ is firm, sharp-edged, maintaining the usual form and notches so that it is easily recognized. The splenic tumor may be entirely lacking. In contradistinction from the myelogenous process, although as Neumann has proven the bone-marrow is regularly involved in lymphatic leukemia, clinical evidence of such involvement, such as tenderness of the sternum or long bones is rarely observed.

Constitutional Symptoms.—Weakness, anemia, prostration, and possibly fever accompany the formation of the lymphatic tumors, and gradually increase with the growth of the local lesions. For long periods the general health may be little affected and the comparative comfort of the patient with considerable enlargement of the lymph-nodes and spleen and the characteristic blood picture is often surprising. Fever may

be entirely absent, and is usually slight, unless induced by secondary septic infection.

Blood Picture. –In the early stages the red cells may show no changes. Gradually as the disease advances the number of red cells and the hemoglobin content fall, usually proportionately. In the severer stages the red cells develop variations in form, size, staining as in any grave anemia, and nucleated forms may appear, but are relatively few. In exceptional cases the red cells show but little change throughout the disease.

The essential feature of the blood picture is the lymphocytosis. The total leucocyte count rarely reaches the enormous numbers seen in myelogenous leukemia. Cabot puts the average at 100,000, Gulland and Goodall estimate it as 150,000, but counts of over 500,000 are not unknown. More important than the total number is the differential count, the lymphocytes almost monopolizing the field and constituting ninety, ninety-six, or ninety-nine per cent. of the white cells.

The size of the lymphocytes varies. It is usually stated that in the chronic type small lymphocytes are found, and in acute cases larger types, but Gulland and Goodall dissent from this view, saying that no rule can be laid down, the size varying in both acute and chronic types, and intermediate forms being often so abundant as to make accurate division impossible. Necessarily the other types of leucocytes are diminished proportionately. Neutrophiles and eosinophiles are few in number. Myelocytes are commonly entirely absent.

The leucocyte increase, as a rule, is found at the first examination, persists throughout the disease, and augments with its progress. Marked remissions or even disappearance of the leucocytosis may occur naturally and considerable recession may be effected by treatment, although the lymphocytes are relatively resistant to arsenic, the Röntgen ray, and benzol.

Apart from these fundamental symptoms of chronic lymphatic leukemia considerable variety may be introduced in the clinical picture by unusual development of the lymphoid deposits in special tissues.

The Skin.—More or less itching of the skin, with or without urticarial eruptions may be observed. Definite lymphoid infiltrations may present themselves under several forms (Oertel): (1) Multiple, circumscribed, pin-head to hazel-nut sized, pale, faintly red or brownish tumors. (2) Few or solitary, brown, markedly elevated and possibly lobulated, firm, slow-growing, and persistent nodules. (3) Diffuse lesions, either moist eczematous areas on the head, extremities, or chest, or tumors of the size of a pea or a pigeon's egg, ulcerating spontaneously and leaving a large, flat, red ulcer.

The Mouth.—Ulcerative and gangrenous processes in the mouth or throat such as will be described under acute lymphatic leukemia are rare in the chronic form, but may be observed in the terminal stages. The parotid and lacrymal glands may be involved in symmetrical growths closely resembling those described as Mikulicz's disease.

The *lungs* are rarely involved except as enlargement of the mediastinal and bronchial nodes may compress the trachea or bronchi; but pleural effusions may develop. Dyspnea is a frequent symptom, caused either by the pressure of enlarged lymph-nodes upon the trachea, bronchi, or the great vessels of the lung, or by lymphoid infiltrations of the walls of the larynx, trachea, or bronchi.

Nervous System.—Various parts of the nervous system may be affected whether by lymphoid infiltrations into and about individual nerves, degenerations of nerve fibers, or hemorrhages into any part of the system. In this manner paralysis of special nerves, such as the facial, or disturbances of sight or hearing may be caused, but such affections are more frequently seen in the acute type of the disease.

In the eye hemorrhages may be seen in the conjunctiva, the iris, or the retina. Leukemic retinitis may manifest itself as scattered hemorrhages, white patches, or whitish linear infiltrations ensheathing the retinal vessels.

Pathological Anatomy. In the corpse the skin is exceedingly pale, edema of the lower extremities or a general anasarca is present, and on account of the wasting the enlarged lymph-nodes stand out like massive tumors in the neck, axillæ, and groins. The blood is pale and watery; its microscopic characters are those already given in the clinical description.

Lymph-nodes. On opening the throat and abdomen more or less marked hypertrophy of the nodes of these regions are found in addition to the subcutaneous masses. The consistency of the nodes varies greatly; they are usually soft, but may be quite hard. The section is reddish or yellowish-gray, smooth, uniform, and shows no stroma. Hemorrhages, either fresh or old, may be found in the substance of the nodes. Necrosis or cascation of the nodes is rarely observed, and if present, is due to secondary infections.

The *spleen* is found enlarged and, like the nodes, either hard or soft. The liver is moderately hypertrophied, its surface and section showing minute or hazelnut-sized, yellowish white or gray nodules of lymphocytic infiltration. There may also be some fatty infiltration of the periphery of the acini.

The *kidneys*, like the liver, regularly show foci of lymphocytic infiltration, either small nodules or stripes. Rarely a definite hemorrhagic nephritis may be observed. The suprarenals may also be the seat of lymphomatous nodules.

The *thymus* gland, in contrast to the conditions found in myelogenous leukemia, is usually large, in some cases extending over the pericardium and even reaching the diaphragm.

The *tonsils* and the lymphatic tissues throughout the alimentary tract may be hypertrophic. In the intestine the hypertrophic lymph follicles may be the seat of necrosis or ulceration. In the larynx and trachea the lymphocytic growths may appear in definite nodules or in diffuse infiltration of the walls of the trachea or bronchi. The skin and the nervous system may be involved, as has been described clinically.

The *bone-marrow*, as has already been stated, is regularly affected in the lymphatic leukemia, though not to the same degree as in the myelogenous type. The degree of involvement varies greatly in different cases; in rare cases the variation from normal may be very slight. The changes are most marked in the marrow of the long bones. The affected bones show red or gray, jelly-like marrow. The marrow spaces are widened, the cortex of the bone often thinned, and filled with widened canals. These spaces are all occupied by invading marrow and even beneath the periosteum lymphoid infiltrations may be found, closely resembling the conditions prevailing in chloroma, as will be later described.

Microscopically lymphatic leukemia is characterized by abundant infiltrations of lymphocytes, either large or small, in all the affected tissues. In the lymph-nodes the distinction between the large-celled keim-centers and the small-celled periphery is lost. Similarly in the spleen, follicles and pulp can no longer be differentiated. In the bone-marrow the normal appearances are lost or obscured by the invasion of lymphocytes. In the liver, kidneys, and other affected organs the invading lymphocytes present themselves either in definite foci made up almost entirely of large or small lymphocytes or in diffuse infiltrations. The accumulations of lymphoid cells may be so abundant as by pressure to produce degeneration or necrosis of the parenchyma cells. Whether in lymph-nodes or other parts the growth of lymphoid cells is usually confined distinctly to the limits of the affected tissue, but in some instances the growths disregard such limi-

tations and spread into the surrounding tissues in such manner as to make it difficult or impossible to draw a sharp line between the process and lymphosarcoma. Some increase of connective tissue regularly accompanies the lymphocyte increase, and in the more chronic cases the fibrosis may be marked.

Acute Lymphatic Leukemia.

It must be clearly understood that the division of this disease into acute and chronic types, while clinically desirable and instructive, implies no sharp line of separation and rests upon no essential differences. The course, of the disease is brief, usually very brief, and certain symptoms or groups of symptoms, which occur rarely or in attenuated form in chronic leukemia become very prominent or indeed dominate the clinical picture.

Occurrence.—Leukemia, all types included, is too rare a disease to permit of satisfactory statistics of the occurrence of the different types. The course of development of our conceptions of the disease has already been sketched in such manner as to show that the chronic types were first recognized and distinguished according to the blood picture. Later acute types were observed. For a long time all of these proved to be lymphocytic in type and it was thought there were no exceptions to the rule. More recently cases of acute myelogenous leukemia have been observed, but these have been exceedingly rare. From certain features of the clinical picture acute lymphatic leukemia may be easily overlooked without blood examinations, or mistaken when blood examinations have been made. It is unquestionable that by reason of more widespread knowledge of the disease and closer attention to blood examinations this particular field is being considerably extended and the number of cases assigned to it is correspondingly large.

Acute lymphatic leukemia may be observed at any age, but appears to be more common in childhood.

Etiology.—Clinically acute lymphatic leukemia strongly suggests an acute infection. Especially in the cases in which ulcerative lesions of the mouth or throat are accompanied by great swelling of the adjacent lymph-nodes, fever, sweating, and the other symptoms of the disease, this interpretation is most impressive. Bacteria of many kinds, are, of course, present in the mouth. Some of these have been found in the lymph-nodes and even in the blood, but none of them with such constancy as to warrant their acceptance as the cause of the disease. We are at present quite as ignorant of the etiology of this, as of the other types of leukemia.

Clinical Description.—The onset is regularly sudden. Out of a clear sky, the patient develops the general or local symptoms of the disease, fever, sweating, prostration, and anemia, or ulcerative processes in the mouth or throat, with or without hemorrhages from the mucous membranes.

In some cases the disease is initiated by a period of indefinite complaints, such as headache and weakness, without apparent cause, but in the course of a few days the fever and sweating begin, the lymph-nodes swell, and the lesions of mouth or throat develop. Once the disease is begun, the course is that of a virulent infection with purpuric symptoms and a rapidly increasing anemia.

Fever is regularly present, high or low, and very variable in its course. It may be absent for a time, and often fails toward the end. The lymph-nodes rarely present the massive enlargement seen in chronic leukemia, and in some cases are but slightly swollen. The cervical nodes are usually most affected. Here the influence of secondary infections from the mouth or throat lesions comes into play. The nodes are usually soft and painless, but in a case recently seen they were so tender and almost fluctuating as to suggest suppuration. Toward the end of life the lymph-nodes may considerably diminish in size.

The *spleen* is enlarged in the majority of cases, but not always. Its size is usually moderate and large splenic tumors are decidedly unusual.

The *tonsils* are often enlarged and not infrequently covered by a gray, necrotic exudate, in which bacteria of many kinds, and even diphtheria bacilli may be found. Hemorrhages into or from the tonsil may complicate the picture.

The *gums* may be swollen and bleed easily. They may show necrotic exudates similar to those described upon the tonsils. In a patient recently seen the gums were swollen to such an extent as almost to cover the teeth; they were deep blue in color and bled easily, so as to suggest strongly the appearance of scurvy.

Hemorrhages from the mucous membranes or into the skin constitute an important feature of acute lymphatic leukemia and explain, in part at least, the rapid anemia. Bleeding from the nose, the cheeks, and gums is especially common, but hemorrhage may occur from any part of the intestinal tract, or from the bladder or vagina. Whenever the hemorrhages into the tissues are extensive, necrosis and ulceration may occur. In this manner destructive ulceration of the cheeks, resembling noma, may develop, or the tonsils and adjacent tissues may be affected. Similar processes in the intestines may cause profuse diarrhea.

Hemorrhages may occur in any part of the central nervous system. In the brain or its membranes such bleeding may give rise to intense headache, mental dulness, hemiplegia, or coma. In the fundus of the eye scattered hemorrhages, often with pale centers, may be seen with the ophthalmoscope. The internal ear may be similarly affected, with resulting deafness or dizziness. Paralysis of peripheral nerves may be caused in like manner. Not infrequently death results from persistent hemorrhage, either by reason of loss of blood or from the involvement of vital centers.

The Blood.—The essential symptom is the increase of the mononuclear leucocytes. The total leucocyte count may reach 500,000, but such figures are rarely attained. In many observations the leucocytes do not exceed 50,000. The increase is wholly in the mononuclear types. The greater number of authorities state that in acute lymphatic leukemia the large mononuclear cells predominate while the small lymphocytes characterize the chronic type of the disease, but, as already noted, Gulland and Goodall take exception to this statement and declare the small lymphocytes are found quite as frequently as the large in the acute conditions. In children especially the small lymphocytes predominate. Whichever type is present the lymphocytes constitute ninety per cent., or even ninety-nine per cent., of the total count. With such an enormous increase in the mononuclear forms there is a corresponding dearth of the polynuclear cells, and especially of the myelocytes, eosinophiles, and other forms characteristic of myelogenous leukemia.

The red cells usually show a rapid decrease, with a corresponding fall in the hemoglobin content. The increase of leucocytes coupled with a loss of red cells may bring the proportion of white to red to 1:3, or even 1:2. With severe anemia the red cells may show nucleated types, and variations in size, form, and staining, such as are seen in pernicious anemia.

The loss of red cells is not constant and rare cases show little, if any, reduction in the number of erythrocytes, or other changes in their character.

Once the blood picture of acute lymphatic leukemia is established it is usually constant. Remarkable variations do, however, occur. The lymphocytosis may vary in type at different stages in the same patient. Thus, the large mononuclear types may predominate at one time, the small at another. Intercurrent septic infection may result in a remarkable fall in the total leucocyte count and retrocession of

the swelling of the lymph-nodes and spleen, which may temporarily suggest marked improvement. In rare instances the leucocyte increase may be very slight or absent altogether in the early stages, the characteristic blood picture appearing only in the terminal stages. It is therefore apparent that in any doubtful case repeated examinations of the blood may be necessary to establish the diagnosis.

The *course* of acute lymphatic leukemia is regularly brief, the duration of the disease varying from a few days to a few weeks. Ebstein gave as the longest duration sixty-three days, Gilbert and Weil 112 days, but it is, of course, impracticable to attempt to set such definite limits; some cases of clinically acute type exceed these figures.

Death is the only outcome, usually resulting from progressive anemia and exhaustion and often ushered in by coma.

Pathological Anatomy.—This presents no essential differences from that of chronic lymphatic leukemia. The changes in the blood, lymph-nodes, spleen, bone-marrow, and other tissues are the same. Hemorrhages, necrosis, and ulceration are more frequent and extensive in the acute form.

The diagnosis of acute lymphatic leukemia must rest upon the recognition of the blood changes. From the variability of the clinical symptoms there is no question that many cases are overlooked and reported as severe purpura, scurvy, morbus Werlhofii, or septic infection. The constantly increasing number of cases reported indicates that acute lymphatic leukemia is the most common of all the leukemias. The blood examination is essential to the diagnosis. The total leucocyte count is usually conclusive in itself, but in any case of doubt the differential count is of greater importance. In no other condition do the lymphocytes form so high a proportion of the total. Even when the total count falls within the limits of a leucocytosis from other conditions, the presence of a lymphocytosis of over seventy-five per cent. is characteristic of a leukemia, and if the proportion of lymphocytes exceeds ninety per cent., as it usually does, no doubt of the nature of the process should be longer entertained.

In doubtful conditions the character of the cells must also be taken into consideration, the large lymphocytes being characteristic of acute lymphatic leukemia. The persistence of a high lymphocyte percentage and the character of the cells are of special import when, for any of the reasons already stated, the total leucocyte count falls below the usual level of leukemia and approaches the limits of an ordinary leucocytosis.

Chloroma.

This is a rare disease characterized by the blood picture of an acute leukemia, either myelogenous or lymphatic, and the development throughout the body of growths having a greenish color (whence the name); these growths having special preference for bone. According to Gulland and Goodall but seventy cases had been reported up to 1912. More than fifty per cent. of the cases have been observed in children, but the disease may develop in adult life. As in leukemia, males are more often affected than females. We have no knowledge of the causation of the disease.

Clinical Description.—The disease may begin either with general weakness and anemia, or with symptoms produced by the local growths which characterize it. These growths show decided preference for certain locations: (1) The bones of the skull and face. Tumors develop about the eye producing exophthalmos and deformities of the face. With these there may be growths in the temporal and occipital regions, and lymphatic deposits in the eyelids, the choroid, or the parotid glands. Disturbance of sight or hearing, or paralysis of various nerves of the facial may be caused by pressure. (2) The vertebræ, ribs, and pelvis. In other cases nodular tumors of varying size may appear all over the body.

In rare instances the growths have been of minor importance, the symptoms have been altogether those of acute leukemia of the ordinary type, and only at autopsy has the greenish color of the deposits in various organs revealed the true nature of the affection.

Hemorrhages from the gums or other mucous membranes, or into the skin or various parts of the nervous system, occur as in acute leukemia.

The blood picture is that of acute leukemia, either lymphatic or myelogenous, the lymphatic being much the more common. Great variability in the leucocyte count has been noted, and cases are not uncommon in which the total count has not exceeded normal limits. Bramwell has reported a case with a leucocyte count of 8,000—ninety-five per cent. being lymphocytes, and Pibram one in which an early count of 10,000 was later followed by another of 800. Transitions have also been noted from aleukemic or subleukemic conditions to the full picture of an acute leukemia. With the changes in the white cells there is usually a rapidly developing anemia.

The pathological anatomy is that of an acute leukemia, with certain features peculiar to chloroma. The tumors, whether of the bone or other tissues, upon section show the characteristic greenish color. Deposits having the same color may be found in the liver, spleen, kidneys, the lymph-nodes, and indeed in any of the organs of the body. The greenish color may appear in some parts and be absent in others. This color fades rapidly on exposure to air and altogether disappears in microscopic preparations. In some cases it has been bleached, in others restored, by peroxide of hydrogen. The exact nature of the pigment has not been made out. Pope and Reynolds regard it as a fatty acid combined with iron. The histological changes correspond to those of acute leukemia.

The diagnosis of chloroma is usually determined only at autopsy. Cases with characteristic growths about the skull and face and the blood picture of leukemia should be recognized during life.

The course of the disease is usually as brief as that of acute leukemia, but Dock has reported a case of a year's duration, and some have even exceeded this.

Treatment can be carried out only along the lines appropriate for acute leukemia.

The Aleukemic Leukemias.

Synonyms: Aleukemia, and true pseudoleukemia.

To do justice to the extraordinary complexity of the phenomena grouped under the heading of leukemia, reference must be had to numerous observations under the paradoxical title of this paragraph.

These cases present the clinical symptoms of a leukemia with the differential features of a leukemia but without an increase in the total leucocyte count. The differential may be that of either myelogenous or lymphatic leukemia, so that Naegeli describes an aleukemic myelosis and an aleukemic lymphadenosis. The great majority of cases have been chronic in type and the aleukemic condition has persisted throughout the course, but in other instances the leucocytes have later increased and the final blood picture has been that of a true leukemia.

In their course, prognosis and treatment these cases present no noteworthy differences from the cases of true leukemia, to which they clinically correspond. Naturally the diagnosis of such a condition can be made only by repeated examinations of the blood

establishing the permanence of the leukemic characters despite the absence of leucocyte increase.

Mixed Leukemia.

The clean-cut separation of myelogenous from lymphatic leukemia, in view of the presence of both types of tissue in bone-marrow, spleen, and other parts of the body, side by side, is very remarkable. That separation is, as a rule, preserved. We never see a lymphatic leukemia becoming myelogenous, or *vice versa*. We find, however, that a few cases are recorded in which, with the total count of a leukemia, the differential presented the features of both myelogenous and lymphatic leukemia—a high lymphocyte percentage, with an unusual number of myelocytes, eosinophiles, and mast cells. As an example the following case may be quoted from Gulland and Goodall: Child, aged five years. Great enlargement of nodes and spleen, retinitis. Red cells 2,610,000; leucocytes 240,000; polymorphs sixteen per cent.; lymphocytes fifty-four per cent.; eosinophiles nine per cent.; mast cells four per cent.; myelocytes seventeen per cent.

Nature of the Leukemic Process.—The facts already set forth reveal the complexity of the problem presented by the leukemias. In the acute forms they present very convincing resemblances to virulent acute infections. Other types suggest relationship to the purely hemorrhagic diseases. In their more chronic forms, and especially in the cases described as chloroma, the processes are highly suggestive of a malignant growth with multiple metastases. Interesting arguments for one or the other of these conceptions can be developed, but the solution of the problem must be determined, not by argument, but by experimental work still to be done.

Therapeutics.

Chronic Leukemia.—There is nothing gained by attempting to discuss the therapeutics of myelogenous and lymphatic leukemia separately. We have no specific therapy for either, and measures applicable to one are applicable to the other. Certain differences in the reaction of the two types to treatment will, however, be noted.

The general management of the patient must depend upon the individual condition. As already noted the weakness and prostration vary greatly in different cases. Some patients are able for long periods to continue their ordinary manner of life, even when this involves laborious work. Doubtless hard physical labor is unfavorable, but the question of interfering with or forbidding it must be decided largely by the patient's circumstances. Recognizing the fact that we cannot hold out the expectation of an ultimate cure, the patient should be permitted, so far as may be reasonable, to continue his usual activities. In the severer cases, and especially in the later stages of the disease, rest in bed is necessary. Particularly is this true when any degree of fever is present. The diet must be suited to the digestive capacity. Restriction should be practised only because of nausea, vomiting, diarrhea, or other definite disturbances of the digestive powers. Because of the tendency to intractable diarrhea care should be taken to avoid the administration of drastic purgatives. Constipation should be treated by mild laxatives or enemata. The condition of the mouth should be watched and a simple antiseptic wash used regularly after meals.

Of medicinal measures arsenic in some form still enjoys high repute. It is best given, as a rule, as Fowler's solution, beginning, for an adult, with a dose of three to five drops well diluted, and increasing the dose a drop a day up to the limit of tolerance. In this manner fifteen or twenty drops may be given after each meal. Care must be taken not to push the administration too far and the dose should be promptly reduced or the medicine discontinued for a time upon the appearance of any indication of intolerance.

Arsenic has also been given hypodermatically in the form of the cacodylate of soda, arsacetin, and atoxyl. A certain danger of producing serious effects upon the optic nerve, and possibly blindness, by either arsacetin or atoxyl given in this manner is admitted, and their use has therefore been abandoned.

Salvarsan by intravenous injection has also been tried in chronic leukemia but without satisfactory results.

Drysdale has reported good results from the administration of naphthalene tetrachloride in eight-grain doses every three hours. Gulland and Goodall noted improvement in one case in which this remedy was given in doses of five to ten grains.

Inhalations of oxygen have also been recommended. The administration of fresh bone-marrow has been tried, but has given no results. Quincke and Pfeiffer advised the use of tuberculin in small doses on the theory that the toxins of many acute infections diseases, and especially of tuberculosis, caused a retrocession of the leukemic growths, but this practice has been abandoned.

The latest, and seemingly the most potent, addition to the list of medicinal remedies for leukemia is benzol, or benzene. It is a product of the distillation of coal-tar, having the formula C_6H_6, and should not be confused with benzine, a distillate of crude petroleum. For this reason the name benzol is decidedly to be preferred. The use of benzol in leukemia resulted from the observation of a series of cases of accidental poisoning from this chemical in the Johns Hopkins Hospital in 1909. Selling, of that institution, in an experimental study of the drug, showed that it possessed decided leucotoxic action. In 1912 Koranyi, of Budapest, on the basis of Selling's observations, employed benzol in the treatment of leukemia with favorable results. Since the appearance of Koranyi's report the use of the drug has rapidly and widely extended, the general consensus of opinion being that it has very decided power to reduce the leucocytosis and the size of the spleen and lymph-nodes, with resulting improvement in the general condition. From his observations Koranyi draws the following conclusions: (1) Benzol first tends to increase the white blood cells, but shortly produces an improvement in the leukemic condition. The fall in the white count usually begins at the end of the second or early in the third week of therapy, the decrease being at first slow, and later quite rapid. (2) Benzol acts more slowly than the *x*-rays, but some patients improve under its administration who have not responded to other forms of therapy. Previous or concomitant application of the *x*-rays seems to hasten the action of the drug. (3) The drug can be safely given in doses of four grams daily, and its administration with equal parts of olive oil seems to lessen the tendency to produce unpleasant symptoms such as heartburn, eructations, or vertigo.

The possibility of remarkable improvement under benzol treatment has been confirmed by many observers. In some of the cases the improvement has amounted to apparent cure, but in none of these has sufficient time elapsed to warrant the conclusion that cure has actually been accomplished. As a rule, despite the disappearance of the high leucocyte count, myelocytes were still present. In not a few cases, after temporary improvement the white cells again rose, the other symptoms became aggravated, and the patients succumbed to the disease. Jesperson and Neumann both report cases in which chronic leukemia, either coincident with or subsequent to treatment by benzol, assumed the character of acute leukemia. Muhlmann and Neumann have reported deaths from leukemia, following the use of benzol and at autopsy the liver was found to show extensive necrosis. Pappenheim has demonstrated the same lesion in the livers of rabbits treated by benzol. Kiralyfi, who has had considerable experience in the use of benzol,

reports a case of uncontrollable nose-bleed coincident with a drop of the leucocytes to 460, and states that death was due to the continuance of the action of benzol. He advises that benzol should be stopped when the leucocytes have dropped to 25,000.

It is therefore evident that benzol, while a potent remedy in the treatment of leukemia, is also a dangerous one, whose administration must be followed with care. Barker and Gibbes advise that its use be confined for the present to hospital patients. At any rate the administration of the drug must be controlled by frequently repeated blood examinations and the remedy stopped when the leucocyte count approaches the limits of an ordinary leucocytosis.

From the reports at hand benzol appears to be more effective in myelogenous than in lymphatic leukemia. In some observations it has failed entirely to affect lymphatic leukemia. Klein, however, finds it equally effective against either type of the disease.

The dosage of benzol, according to Koranyi, should be 0.5 gram, three or four times daily, mixed with an equal quantity of olive oil, and dropped into capsules immediately before administration. The dose may be increased gradually up to the amount of four grams per day. As already noted, frequent blood examinations are necessary during its administration and the remedy must be lessened or stopped upon any pronounced fall of the leucocytes, to avoid too severe action upon the blood-forming tissues.

The Röntgen-ray treatment of leukemia was introduced by Senn in 1902 and has since won general recognition as a very important agency in the control of this disease.

The action of the rays is explained as an elective destructive action upon the lymphatic and myelogenous tissue exposed to this influence, in the spleen for example. As a result of the local destruction of many cells and the taking up of their products substances which are toxic to similar cells pass into the circulation and exert an inhibitive action upon the leukemic processes throughout the body. The action of the rays is, therefore, not merely a local destruction of the leukemic cells but at the same time an inhibition of the disease process.

The technique of Röntgen-ray therapy varies greatly in different hands. Pancoast of Philadelphia exposes in series the different parts of the bony skeleton, excepting the head, and advises that symptoms of intoxication be met not by stopping the treatment but by lessening the dose. Exposures are made daily with careful regulation of the dosage to secure the desired result without producing increased toxemia, and are continued until normal conditions, or as nearly normal as possible, are obtained. The total leucocyte count and differential are held to be the best guides as to the effects of the treatment. The use of arsenic, as an adjuvant, is advised either for anemia or for a stationary high leucocyte count. In acute leukemia the use of the rays is found harmful.

Suter of Zurich on the other hand directs the treatment to the spleen, exposing it on the first day from in front, the next from the left side, and the third from behind. A dose of eight to ten X (Keinboeck units) is ordinarily given, a less quantity to weak or anemic individuals. After two or three weeks a new series of treatments is begun. Suter uses a medium, soft tube at a distance of about twenty-five centimeters. He claims the best and most lasting results from the treatment of the spleen. Pancoast and Stengel, after trying exposures of the spleen, have adopted the practice of treating the bones. The treatment should be undertaken only by one having experience in the effects of the rays and every precaution should be taken to prevent local burning or the production of ulcers. The effect of treatment must be judged by the general condition of the patient and frequent blood examinations. In favorable cases the enlarged organs are reduced in size and the blood count approaches normal. Effects are likely to be much less in lymphatic than in myelogenous leukemia. In any event the disease is not cured, but after a period of quiescence the inevitable relapse occurs and death ensues. Some prolongation of life with greater comfort and well-being is the best that can be promised.

Naegeli gives as contraindications to the continuation of the Röntgen-ray treatment: (1) fall in the hemoglobin and number of erythrocytes; (2) any lasting aggravation of the general symptoms, fever, diarrhea, sweating, etc.; (3) rapid drop of the white cells from a high total to normal or subnormal figures; (4) considerable rise in the number of myeloblasts.

Thorium X and direct exposure to the sun's rays have both been used in the treatment of leukemia, but little is known as to results.

Surgical removal of the spleen or other leukemic tumors has been attended by such bad results as to contraindicate radical procedures.

Acute Leukemia.—The treatment of acute leukemia of either type must be wholly symptomatic and conservative. Every effort at active treatment of these cases has either failed of definite result or has done harm. Injections of salvarsan, the *x*-rays, transfusion of blood, etc., have all failed at times, and in some cases have aggravated the symptoms. The general management of the patient should be that appropriate in an acute infectious disease (typhoid fever). Local measures may be employed to check hemorrhages from mucous membranes. Anodynes may be required to relieve distress. David Bovaird.

Leukerbad.—See *Loèche-les-Bains.*

Levico.—A village in the Austrian Tyrol, near the Italian frontier, 1,640 feet above sea-level, noted for its extraordinary arsenic waters. It is twenty-four miles by rail from Trent, which is on the main Brenner Pass line running from Innsbruck to Verona.

Its situation is very picturesque, at the entrance of the Lugano Valley, surrounded by the beautiful mountain scenery of the southern Tyrolese Alps. A short distance up the valley are two attractive lakes.

The mineral springs arise from two grottoes, called the Grottoes of Vetriola, in the side of Monte Fronte, three hours distant, at an elevation of 3,000 feet above sea-level.

These springs belong to the class of arsenical waters of which Roncegno, five miles distant, and La Bourboule in France are other examples. Those of Levico, however, are some of, if not the strongest of all natural arsenical waters known, containing one-twelfth of a grain per pint, and are administered in doses of one or two tablespoonfuls or less daily, diluted in milk or plain water. Besides the arsenic there are also considerable quantities of iron and manganese in addition to many other mineral salts. Of the two springs, one is called the weaker and the other the stronger, depending upon the amount of arsenic contained; of the weaker 1,000 parts have been found to contain 0.0009 parts of arsenious acid, and of the stronger 0.008 parts. The strong spring also contains 1.6 iron sulphate and the weak 0.37.

The water has been found beneficial in those conditions for which arsenic and iron are indicated, such as anemia, chlorosis, nervous affections, especially neurasthenia and chorea, uterine and ovarian affections, skin diseases, such as eczema, lichen, psoriasis, malaria, and gastrointestinal disorders.

At the springs only the weaker is used internally, and the stronger for bathing, both being diluted with pure spring water as prescribed by the attending physician. In the internal use, one begins with a tablespoonful of the weaker water, well diluted or a third as much of the stronger, morning and evening. The dose is gradually increased until three tablespoonfuls are taken after each meal.

There is a kurhaus with eighty bath-rooms and facilities for various forms of hydrotherapy and electrical treatment. After the baths vaseline is used to rub on the skin, on account of the irritant effect of the water.

There are also mud and grape cures.

The season extends from June to September.

The accommodations are good, there being a number of comfortable hotels. There is a well laid-out park with pavilions, and pleasant excursions in the vicinity. The climate is mild, but hot in summer.

EDWARD O. OTIS.

Levisticum.—LOVAGE ROOT. The root of *Levisticum levisticum* (L.) Lyons. This is a large, aromatic, yellow-flowered perennial herb, with a short, thick, fleshy rootstock, from which several large, simple roots are given off below, and three or four stout, upright, slightly branching stems above. All parts of the plant have a strong and rather agreeable fragrance, due to its peculiar essential oil, and the root contains also considerable resin. When fresh, the stem and leaves exude a yellowish latex upon being broken.

Lovage is said to be truly wild only in Southeastern Europe (Bosnia and Servia, Flückiger), but it has been cultivated for centuries in other parts of Europe, and is extensively naturalized. That of commerce comes principally from Holland, Germany, and France. It is at present cultivated upon a small scale in the United States. The "root" is most in demand, although the fruit has more oil. It consists of the rhizome split or quartered, and, more abundantly, of the roots themselves, either whole or split. The pieces are of a brown, gray-brown, or black color externally, transversely marked near the top, elsewhere deeply longitudinally wrinkled and shrivelled; section white, yellow, or reddish; resin canals visible; texture spongy and flexible. Odor and taste peculiar, aromatic, resinous, bitterish-sweet, angelica-like. It is very prone to being worm-eaten, and an article entirely free from this defect is difficult to obtain. *Essential oil*, *resin* (yielding umbelliferon), *malic* and *angelic acids*, *gum* and *sugar* are among its constituents; to the first two it owes its medicinal value, whatever that may be.

It is a rather pleasant stimulant, aromatic, and diuretic, of the angelica and musk-root kind, with no active properties. It is sometimes given as a diuretic in dropsies from heart disease, etc., also for catarrh of the bladder, and for chronic bronchitis. It is, however, little used in this country, and even abroad has degenerated mostly to the level of a condiment among the country people.

Oil of lovage is an article of commerce, existing in three forms—from the root, from the fruit, and from the fresh herb. Although differing in specific gravity and slightly in flavor, they are very similar.

W. P. BOLLES.

Levret, André.—The most distinguished accoucheur of the middle portion of the eighteenth century, an able author, and a general surgeon of marked ability. He was born at Paris in 1703. In 1747, when he published his first treatise on this branch of surgery, he had already for a long time been giving courses of instruction in midwifery to men who, like Roederer, Grantz and Stein, were afterward to attain great distinction as practitioners and teachers in the same line of work. He was a member of the Royal Academy of Surgery, and the accoucheur of the Dauphine of France. He died at Paris, January 22, 1780.

Since the time of Mauriceau no other obstetrician had gained so high a degree of distinction as had Levret; and, besides, he was a very clever general surgeon. It was he, for example, who brought about the general use of the ligature in the treatment of uterine polypi, and, in order to facilitate the successful employment of this procedure, he invented certain instruments which afterward served as the basis for more modern patterns. Of his published writings the following deserve to receive special mention: "Observations sur les causes et les accidents de plusieurs accouchements laborieux, avec des remarques, etc.," Paris, 1747; "Observations sur la cure radicale de plusieurs polypes de la matrice, de la gorge et du nez, opérée par de nouveaux moyens inventés par M. A. Levret," Paris, 1749; and "L'Art des accouchements, démontré par des principes de physique et de mícanique; pour servir d'introduction et de base à des leçons particulières," Paris, 1753. A. H. B.

Levulose.—Fructose, Fruit Sugar. See *Aliment*.

von Leyden, Ernst.—One of the great clinical teachers of modern times. Born at Dantzig, Germany, April 20, 1832. He studied medicine at the University of Berlin, chiefly under Schoenlein and Traube, and received his doctor's degree in 1854. Then, after serving for eleven years as a military surgeon, he accepted a call to occupy the Chair of Medicine at the University of Koenigsberg, in eastern Prussia. Here, in association with von Recklinghausen and Spiegelberg, he inaugurated a new era of clinical teaching. Then, in 1872, he was transferred to the newly established Kaiser-Wilhelms-University in Strassburg, where he continued to carry on his very successful clinical teaching. In 1876 he was appointed Traube's successor in the Chair of Medicine, at the University of Berlin, and after the death of von Frerichs, in 1885, he took charge of the latter's First Clinic. In 1894 he made a long stay at the Russian Court, to which he had been summoned to undertake the treatment of the Emperor Alexander, and in the following year a patent of mobility was conferred upon him in recognition of his valuable services. He died in 1910.

The following are among the more important of von Leyden's published writings: "Die graue Degeneration der hinteren Rückenmarksstränge," Berlin, 1864; "Die Klinik der Rückenmarkskrankheiten," Berlin, 1874–1875; and "Handbuch der Ernährungstherapie," two volumes, Leipzig, 1898. von Leyden's latest writings will be found in the *Zeitschrift für klinische Medizin*, the *Zeitschrift f. physikal.-diätet. Therapie*, the *Deutsche Klinik*, etc. A. H. B.

Leydenia.—A generic name given to a certain ameboid stage in the life cycle of the *Chlamydophrys stercorea*, the only entozoic member of the protozoan order Foraminifera. This parasite has been found in the feces of various vertebrates. It is usually a harmless inhabitant of the hind-gut, but sometimes passes into the peritoneal cavity and multiplies as an ameboid form, *L. gemmipara*. See *Protozoa*.

A. S. P.

Leysin.—This mountain village is a high-altitude resort, 4,757 feet above the sea-level, situated in western Switzerland at the junction of the Ormont and Rhone valleys, a few miles from the eastern end of Lake Geneva. It is easily reached from Paris by rail to Lausanne and Aigle, and thence by an electric road.

Tuberculosis is the principal disease treated at this resort for which there are several large sanatoria, although the climate is recommended for bronchial asthma, chronic bronchitis, anemia, convalescence from pneumonia and pleurisy, neurasthenia, and obstinate dyspepsia. The climate is favorable for a continuous residence the year through. The peculiarities of a high-altitude climate, such as have been

described under Davos and elsewhere in the HANDBOOK, are exhibited at Leysin: a comparatively dry, pure atmosphere, a large amount of winter sunshine, freedom from mists and high winds, and intense solar radiation, characteristic of the attenuated air of altitudes. The meteorological data are similar to those given under Davos. The average winter temperature, however, is somewhat higher than that at Davos, ranging from a minimum of 21.7° F. to a maximum of 35.6° F. at 7 A.M., and from a minimum of 25.8° F. to a maximum of 39.1° F. at 10 A.M. The lowest temperature observed was −2° F. The sun temperature in winter is between 86° F. and 122° F., while the ordinary temperature is between 32° and 50° F. The mean relative humidity for the five winter months, November to March inclusive, for the three winters 1887–90, was 61.9 per cent. There are on an average from five to five and a quarter hours of sunshine a day, though the possible daily insolation is, of course, greater. The total number of hours of sunshine for the five winter months from 1887–90, was as follows: 1887–88, 482.70 hours; 1888–89, 601.05 hours; 1889–90, 737.6 hours, or a little over four hours a day.

In the four years 1887–90 the percentage of calm days (absence of wind) was 81. Wind, therefore, is the exception. The prevailing direction of the wind is from the southwest and southeast. Fog or mist is rare.

Leysin, then, well fulfils the conditions of a high-altitude health resort, which are: (*a*) purity of the atmosphere; (*b*) dryness; (*c*) absence of wind; (*d*) intense insolation; (*e*) low temperature; (*f*) diminished barometric pressure.

Above the village of Leysin, which is itself situated on a plateau, is the plateau of Feydey, 610 feet higher, and here is situated a sanatorium with a large annex. To the north, northeast, and northwest rise chains of mountains which afford protection from the winds blowing from these directions. The sanatorium is situated on the border of great forests of fir trees which clothe the mountain sides. In front of the sanatorium is a great terrace looking toward the south, and affording a wide and extended view. This sanatorium, which with its annex, has one hundred and forty chambers, is equipped with all the appliances for modern sanatorium treatment, and is under skilful medical direction. Those suffering from pulmonary tuberculosis who are most likely to improve in this, as in all high-altitude health resorts, are those whose general condition is good, and in whom the involvement of the lungs is not too extended or active, as indicated by continuous pyrexia. At Leysin is also situated Rollier's celebrated sanatorium for children suffering from surgical tuberculosis, an important feature of the treatment of which is heliotherapy (see the article with this title on page 138). The best time of the year in which to begin a residence in Leysin is in August or September.

As has been mentioned above, the "cure" can be continued the year through, though for those who spend the winter in the south Leysin affords a favorable summer climate. There are many attractive mountain excursions about Leysin, and in the winter there are skating and tobogganing. There are Catholic and Protestant churches, shops, and attractive chalets which can be hired for the season. The postal and telegraphic facilities are good.

To one desiring to take the high-altitude cure in a well-conducted sanatorium and at the same time gain a knowledge of French and French people, Leysin can be recommended. EDWARD O. OTIS.

Liberty, Sullivan County, New York.—Sullivan County occupies a position near the summit of the eastern water-shed of the Delaware River, south of the Catskill Mountains at a point where the boundaries of New York, New Jersey, and Pennsylvania meet. The country is beautiful, hilly, but not wild; it is devoted to dairy farms and supports a prosperous community. There are no large bodies of water near, no swamps or stagnant water-courses, and rapid drainage gives to the air a dryness not found in the lake region or at the seaboard. The soil in the lower levels is a loam with a moderate amount of clay, but on the hillsides it is more porous. The range of temperature is great; there are usually four months of sleighing, the snow which falls in November remaining dry and hard through March. The mean annual temperature is 41° F., and the mean annual rainfall about fifty inches.

The death rate for Sullivan County and for Delaware County adjoining is the lowest in the State, being about one-third that of New York City. The native population is of hardy Dutch stock with very little foreign blood.

The neighboring towns of Liberty Falls, Fallsburg, Woodburne, Youngsville, Parksville, Neversink, Monticello, and Hurleyville, although not quite so high as Liberty (elevation 1,600–2,200 feet), share in great measure its natural advantages and are attractive for summer residence.

As a winter resort Liberty is attractive. There are about one hundred hotels and private houses that afford accommodations during the summer. Access is by the New York, Ontario, and Western Railway in about four hours from New York.

Liberty was selected by the late Dr. Alfred L. Loomis as the site of the sanatorium which now bears his name. This institution was opened in 1896 and has been liberally equipped for the treatment of tuberculous patients. There are three divisions, one for patients paying from fifteen to forty dollars weekly, the annex for patients paying seven dollars weekly, and an intermediate division with a rate of ten dollars per week. Special arrangements can be made for private cottages and suites. There are at present twenty-seven buildings with a total capacity of 190. Only those patients are desired who are in the early satges of consumption, and to whom a residence of a number of months in the sanatorium promises a complete cure or such an improved condition that they can return to their homes and be able to carry on their work. Both men and women are admitted. Patients are required to live a continuous out-of-door life both summer and winter. Climate is not wholly relied upon in the treatment of patients, for use is made of appropriate medical treatment as well. Among the special measures used are a system of graduated labor, the induction of artificial pneumothorax and the systematic use of tuberculin in selected cases. About 4,000 patients have been treated, data regarding whom may be found in the annual reports. The post-office address of the sanatorium is Loomis, Sullivan Co., New York. GUY HINSDALE.

Libraries, Medical.—The best definition of a library (from Latin *liber*, a book) coincides with Carlyle's definition of a university as "a collection of books." The making of such a collection implies a civilization already specialized to the extent of transferring thought or tradition to some form of inscriptions or script. In this connection, it is customary to differentiate from libraries proper such archival collections as the picture writings made on the sides of cliffs by Australian savages, Aztecs, and North American Indians, all hieroglyphic, cuneiform and runic records, the leaden *κατάδεσμοι* ("impreçationary tablets") found in the temple of Demeter at Cnidus, or the votive tablets (*ἀναθήματα*) suspended in the tables of Æsculapius, limiting the contents of a library, in the strict sense, to miscellaneous collections of written or printed literature in portable form. For example, a general collection, not purely archivistic,

of papyri, of inscribed clay bricks such as Layard found at Nineveh, of Chinese writings on slips of silk or bamboo, of Burmese palm-leaf inscriptions, or of Greek or Roman parchment rolls, would already be a "library"; and from the evidence of the Ebers, Brugsch, and Hearst papyri it is fair to assume that even the Egyptians and Babylonians had made such collections of medical works. It is said that there was a special collection of medical books at Cnidus. Aristotle, who was an Asclepiad, had, according to Athenæus, a private library which he bequeathed to his pupil, the botanist-physician Theophrastus, after whose death it eventually fell into the hands of Ptolemy Philadelphus. According to Strabo, Aristotle was the first person to collect a library and the great Alexandrian collections perhaps originated through the fact that he communicated his taste to the Egyptian monarchs.

Under the Ptolemies, two great libraries were built up at Alexandria, the Serapeum, containing 42,800 rolls, and the Brucheum, containing 400,000 rolls. In these libraries the first experiments in bibliography were made. The tragedies and comedies were catalogued by order of Ptolemy Philadelphus, and Callimachus made a list of all the principal books, arranged in 120 classes. The Brucheum was destroyed when Caesar set fire to the fleet in the harbor of Alexandria. To make good the loss, Antony presented to Cleopatra the library from Pergamum, after which the Serapeum became the principal library. The Brucheum was again destroyed under Aurelian (A.D. 273) and the Serapeum under Theodosius (*circa* 389–391). After the conquest of Alexandria in 640, according to the chronicler Abulfaraj, the Saracens again destroyed the great Alexandrian libraries by order of the caliph Omar. This has been doubted by Gibbon and the later historians, because there is complete silence about it in all other contemporary records.

The Romans did not begin to have libraries until the second century B.C. The first they acquired were spoils of war, those brought from Macedonia by Æmilius Paulus in 167 B.C. Later, Lucullus, Cicero, Terence, and Atticus had fine collections, which became a fashionable folly of the rich and were ridiculed as such by Seneca and Lucian. According to Pliny and Ovid, the first to erect a public library was Asinius Pollio. Sometime later, Augustus Cæsar established the Octavian (33 B.C.) and the Palatine libraries. Tiberius, Vespasian, Domitian, and Hadrian followed suit, and by the fourth century, it is said that Rome had 28 public libraries, and about the same number in the provinces. Many of these libraries were destroyed by fire. Great collections were also built up under the Eastern Empire at Constantinople, and, as Christianity spread, these became more and more ecclesiastical in character. One good thing Byzantium did for medicine. It was a sort of cold storage plant for Greek literature, and after the fall of the Eastern Empire, its wandering scholars became disseminators of new learning and forerunners of the Renaissance. In the Western Empire, the invading barbarians destroyed everything and the Church was for a long time hostile to profane letters and science.

There were libraries in the Middle Ages but they were nearly all monastic in character. The most famous were those founded at Monte Cassino, Tours, by Alcuin, at Fulda (774), at Fleury, at Cluny, the Benedictine libraries, and those of the English cathedral towns, Canterbury, York, Wearmouth, Whitby, Glastonbury, Peterborough, and Durham. In these priories and cloisters, the books were either kept in chests (*armaria*) or chained to shelves in the walls. With the rise of the great medieval universities, medical teaching began to be specialized and small collections of medical books formed the nucleus of libraries, being usually the Greek and Arabian writers specified by Haeser as the text-books in the curriculum. The Arabians, at first hostile to alien literature, became patrons of learning and science and built up great libraries at Bagdad and Cordova, Cairo and Tripoli. Under the Ommiades (Western Caliphate) there were some seventy libraries in the cities of Andalusia. In Italy, the greatest of the medieval libraries was the splendid Biblioteca Vaticana at Rome. Cosimo de' Medici founded a library at Venice in 1433. The Biblioteca Estense at Modena was founded in 1393. The first modern public library was founded by the Italian humanist Niccolò de' Niccoli (1363–1437) who left 800 volumes to the city of Florence in 1436. The Bibliothèque nationale at Paris was founded about 1367. Among the famous English libraries of the pre-Renaissance period were those founded at Balliol (1268), Oriel (1330), Merton (1370), Queen's (1400) and Lincoln (1427) Colleges, Oxford; and at Peterhouse (1284–5), Clare (1346), and Gonville and Caius (1348) Colleges, Cambridge. The Library of Trinity Hall, Cambridge (1350) still has some of its books in chains. The Cambridge University Library proper was founded prior to 1444, the Imperial Public Library of Vienna in 1440 and the Library of St. Mark at Venice in 1468.

With the invention of printing (*circa* 1448), the modern period of libraries begins, and the printing of medical literature soon became a specialty in itself. The first medical publication to be set in type was, in fact, the Purgation-Calendar in the Bibliothèque nationale at Paris, which was printed with the types of Gutenberg's 36-line Bible, and is only a sheet of paper. Other medical incunabula were soon printed in quantity, the earliest known being the Blood-Letting Calendar of Mainz (1462), Roland of Parma's pest-tract of 1468, Giammatteo Ferrari's Practica (1469), and the pest-tract of Valescus de Taranta, the Pandects of Matthaeus Sylvaticus, and the Aggregator of Giacomo de Dondis, for each of which the date 1470 has been assigned by some scholars. Collections of medical manuscripts and of printed medical texts now began to be a definite part of the university libraries of the Renaissance period and, given the interest which was excited by the beautiful imprints of the Aldi and Giunti, of Oporinus and Frobenius, of Elzevir and Plantin, it is reasonable to suppose that many fine private collections were made, especially by the great Renaissance editors and commentators, Leonicenus, Linacre, Rabelais, Anutius Foesius and the rest. Small collections of books no doubt existed at some of the mediæval hospitals, such as St. Bartholomew's and St. Thomas's or in the libraries of the different university foundations, *e.g.* Queen's (1448), St. Catherine's (1475), Jesus (1496), St. John's (1511), Trinity (1546), and Emmanuel (1584) Colleges, Cambridge, Magdalen College, Oxford (*circa* 1456–8) or the University Library at Aberdeen (1494). Of libraries of special interest to medicine, we may instance those of St. Bartholomew's Hospital (1422), the Royal College of Physicians of London (1525) the Imperial Public Library at Vienna (1440), the University Library at Edinburgh (1583), the great Medicean or Laurentian library at Florence (1571), and the Royal Library at Munich, founded by Duke Albrecht V of Bavaria (1550–79) and for a long time the largest collection of books in Germany.

In the seventeenth century, an age of individualism, remarkable advances in science were made through the intellectual valor of isolated workers, and the collectivist spirit went into a period of decline. For such men as Harvey, Malpighi, Stensen, Kircher, and Sanctorius, private collections of books were no doubt a necessity, although Sydenham, Redi, Leeuwenhoek, Swammerdam, Mayow, and Wiseman probably cared more for the direct investigation of natural phenomena. A good index of the *Zeitgeist* is to be found in the fact that William Gilbert (1540–1603), physician to Queen Elizabeth and James I, left a valuable collection of books to the Royal College of Physicians, which were destroyed by the Great Fire of London in 1666. Of public collections of interest to medicine,

probably the most important were the libraries of the University of Bologna, founded by the naturalists Ulisse Aldrovandi in 1605, the Arcispedale de Santa Maria Nova, Florence (1679), the Royal College of Physicians of Edinburgh (1681), the Faculty of Physicians and Surgeons of Glasgow (1698), and such fine collections as the Bodleian at Oxford (1602), the Stadtbibliothek of Hamburg (1648), the Royal Library of Berlin (1661), the Library of the Royal Society (1662), the Advocates Library of Edinburgh (1682), and the Biblioteca Casanatense at Rome (1698). Harvard College (1638) was originally a collection of books and a New York City Library was founded in 1692.

In the eighteenth century, many practitioners of internal medicine acquired large fortunes and enjoyed a certain leisure which eminently fitted them to be virtuosi in the collection of books and curios. Before the year 1733, the Faculty of Medicine of Paris possessed only thirty-two books, but, in that year, largely through the good offices of its Dean, the elder Baron, it acquired from François Picoté de Bélestre (1661–1733), one of its graduates, a bequest of 2,273 volumes, since which it has grown to be the largest medical library of modern times. The Library of the British Museum, now the largest and most important collection in the world, owed its inception largely to the purchase of a collection of books and MSS. from the estate of a physician, Sir Hans Sloane (1753). Another physician, John Radcliffe, founded the Radcliffe Library at Oxford by a bequest of £350 per annum and £40,000 for a building. In 1711, the Italian clinician Lancisi founded the Biblioteca Lancisiana at Rome, a famous collection of valuable medical books. Thomas Cadwalader, M. D., was one of the founders of the Philadelphia Library (1731), and its director (1731–9). Benjamin Franklin, who had much to do with medicine, was the originator of subscription libraries (1731), and, as founder, first president, and historian of the Pennsylvania Hospital (1751), he may be regarded as a founder of its medical library (1760), the first of its kind in America. Haller, Scarpa, Heberden, Hufeland, Van Swieten, Werlhof, and other medical scholars had, no doubt, valuable collections, and even the elegant laity sometimes collected rare medical books. An English black letter of Guy de Chauliac in the Surgeon General's Library contains the book plate of David Garrick. The finest private medical libraries of the period in England were those of Richard Mead, which was auctioned in 1754 for £5,496, Anthony Askew, which brought £4,021 in 1775, and William Hunter's splendid collection of 7,000 volumes, which passed through Matthew Baillie's hands to the University of Glasgow. The Imperial Public Library of St. Petersburg, now containing about 2,000,000 volumes, was based upon a collection of books seized by Czar Peter during his invasion of Courland in 1714; it was thrown open to the public in 1747, and subsequently enriched by the great Zaluski collection in 1795. In this period, too, were founded many other well-known secular or municipal libraries. Among the larger collections of this kind were those of the Admiralty, London (1700), Dijon (1701), Aix en Provence (1705), All Souls, Oxford (1710), Turin (1720), Isle of Jersey (1736), Bordeaux (1738), Nantes (1750), the British Museum, London (1753), the Sorbonne at Paris (1762), the Royal Irish Academy, Dublin (1765), Stuttgart (1765), Leeds (1768), the Royal Academy, London (1769), Milan (1770), Grenoble (1772), Parma (1779), the Society of Antiquaries of Scotland (1780), the Literary and Philosophical Society of Manchester (1781), Toulouse (1782), the Royal Society of Edinburgh (1783), Nice (1786), the Royal Physical Society of Edinburgh (1790), Leicester (1790), Cork (1790), Lisbon (1796), the Athenæum, Liverpool (1798), The Hague (1798), Marseilles (1799), and the India Office, London (1800). The best administered library of the eighteenth century is said to have been that of the University of Göttingen (1736–7). Besides those already mentioned, the important medical libraries of the period were those of the Royal College of Physicians of Ireland (Dublin, 1713), the Royal Medical Society of Edinburgh (1737), the London Hospital Medical College (1740), the Manchester Royal Infirmary (1752), Heriot's Hospital, Edinburgh (1762), the Senckenberg Foundation, Frankfort on the Main (1763), the Medical Society of London (1773), the Wills Library of Guy's Hospital (1777), the Liverpool Medical Institute (1779), the Royal College of Surgeons of Ireland (Dublin, 1784), the Aberdeen Medico-Chirurgical Society (1789), the Société de médecine of Lyons (1789), the Medical Society of Plymouth (1794), the Kaiser-Wilhelms Akademie, Berlin (1795), the Société de médecine of Paris (1796), the Société de médecine et de chirurgie of Bordeaux (1798), and the Royal College of Surgeons, London (1800).

In the year 1800 there were some 102 public libraries in the United States, including those of Harvard University (1638), New York City (1692), Yale College (1700), the College of William and Mary at Williamsburg, Virginia (1700), the Library Company of Philadelphia (1731), the Charleston (S. C.) Library Society (1748), Princeton (1755), Columbia (1757), Brown (1769), Dartmouth (1770), Georgetown (1791), Colleges and the Massachusetts Historical Society (1791). Of these 102 libraries, eight were medical, viz., those of Pennsylvania Hospital (1763), the Medical Department of the University of Pennsylvania (1765), Harvard Medical School (1782), the College of Physicians of Philadelphia (1789), the Medical Society of South Carolina (Charleston, 1789), the New York Hospital (1796), the Medical Department of Dartmouth College (Hanover, N. H., 1796), and the Worcester District Medical Society (Worcester, Mass., 1798).

In 1800, the Royal College of Surgeons of England was chartered and this date marks also the foundation of its fine library, now numbering 60,000 volumes. On September 16, 1800, the Medico-Chirurgical Academy of St. Petersburg, originally two hospital medical schools of 1733, was housed in appropriate buildings, becoming the Imperial Military Medical Academy in 1808. Its magnificnet library was, for more than a century, to maintain its position, after that of the Paris Medical Faculty, as the second largest medical library in the world. The first Russian medical society to be founded, the Imperial Medical Society of Wilna (1805), has now a library of 19,087 volumes. At present (1914), the largest medical libraries of Europe are those of the Paris Medical Faculty (210,000 volumes), the St. Petersburg Military Medical Academy (179,572), the Royal Academy of Medicine of Belgium (100,000), the Royal Society of Medicine, London (80,000), the Kaiser Wilhelms Akademie at Berlin (69,000), the Munich Medical Society (66,075), the Royal College of Surgeons, London (60,000), the Royal Academy of Medicine of Turin (60,000), and the Academy of Medicine of Paris (60,000). To the nineteenth century belong, too, such great secular collections as the Library of Congress, at Washington (1802), the Széchenyi National Library at Budapest (1802), the Imperial Public Library at St. Petersburg (1814), the University Library of Berlin (1831), and the public libraries of Boston (1854), Chicago (1872), and New York (1895).

By the centennial year (1876), there were 3,650 public libraries in the United States, of which sixty were medical. The earliest of the latter in the first half of the nineteenth century were those of the Essex South District Medical Society, Salem, Mass. (1805), the Medical College of Ohio, Cincinnati (1819), the Medical School of Maine, Brunswick (1820), the Medical and Chirurgical Faculty of Maryland, Balti-

more (1830), the Medical College of Georgia, Augusta (1831), the Medical Department of Louisiana State University, New Orleans (1834), the Erie County Medical Society, Buffalo, N. Y. (1835), and the Albany Medical College (1839). The most important of these was the Library of the Medical and Chirurgical Faculty of Maryland, which first got an appropriation for medical books ($500) on June 7, 1830, published a catalogue in 1835, and acquired a handsome new building in 1908.

The enormous increase in the number of medical periodicals has made the nineteenth century the age *par excellence* of specialized collections of medical books, having a local habitation and a name. One reason for this is to be found in the increase of societies devoted to medicine and its branches, the tendency being most prominent in countries having great extent of territory, like the United States or Russia. The United States has, in fact, not only the greatest medical library in the world but also the largest number of separate medical libraries of any country in the world. This was mainly due to the energy, perseverance and ability of a medical officer in the United States Army, Dr. John Shaw Billings (1838–1913), of Indiana, who, even as a medical student, had dreamed of establishing such a collection and at the same time of preparing "a comprehensive catalogue and index which would spare medical teachers and writers the drudgery of consulting ten thousand or more different indexes or of turning over the leaves of as many volumes to find the dozen or so references of which they might be in search." After a remarkable career as army surgeon during the Civil War, Billings was assigned to the Surgeon General's Office at Washington in 1865, and here he found his opportunity. Prior to Surgeon General Lovell's time (1836), there had been a small office collection of books in his administrative bureau which had been increased by Surgeon General Hammond to the extent of about 1,000 volumes. There was also a slush fund of about $80,000 turned in from the military hospitals at the conclusion of the war and, at Billings's instance, the Surgeon General was permitted to use this to increase his collection of books. Upon this basis, Billings began to buy medical periodicals and books of value in large numbers and, in due course, succeeded in obtaining liberal appropriations from Congress in aid of what was even then regarded as the national collection. About 1872, he began the work of indexing the periodicals, and in 1876, published a "Specimen Fasciculus of a Catalogue of the National Medical Library," consisting of a combined index of authors and subjects arranged in dictionary order in a single alphabet, which was submitted to the medical profession for criticism and suggestions. In 1880 appeared the first volume of the analytical Index Catalogue, which has been continued, one volume annually, to date and now (1914) numbers thirty-five volumes. In this work, Billings had the able assistance of Dr. Robert Fletcher, of Bristol, England, and with him founded the extra-official periodical, the Index Medicus, which is a monthly bibliography of the world's medical literature. It was discontinued in 1896, but was revived by the Carnegie Institution of Washington in 1903 and is still current. Prior to 1911, all other medical libraries were outpaced in extent by the great collection of the Paris Medical Faculty (170,000 volumes) and the Imperial Medico-Military Academy of St. Petersburg (175,000 volumes). At present the Library of the Paris Faculty, with 240,000 bound volumes and 800,000 pamphlets, is still in the lead, while the Surgeon General's Library at Washington takes the second place, with 220,749 volumes, 331,802 pamphlets, and 5,190 portraits. On account of its unrivalled collection of periodicals, however, the latter is usually regarded as the best working medical library in the world.

Billings's example soon gave impetus to the library movement which has been continuous to date, and as a result of this the United States has now some 167 medical libraries. The Boston Medical Library was started as a library association on August 20, 1875, with Oliver Wendell Holmes as president, and through the enthusiasm and ability of Drs. James R. Chadwick and Edwin H. Brigham, who were in close touch with Billings, had about 8,000 volumes when it was housed at 19 Boylston Place, in 1878. Although the New York Academy of Medicine was founded in 1846, yet, according to Dr. Jacobi, there were neither books nor reading room for many years. Its library was started by donations in 1877, never bought a book until 1879, but now has a good endowment and income and was housed in a handsome building in 1890.

After the Surgeon General's Library, the Library of the College of Physicians of Philadelphia is the second medical library in size and importance. In 1876, it had 18,753 volumes. According to the recent report of its librarian, Mr. Charles Perry Fisher, it now has 101,340 volumes and 84,807 pamphlets. The next in order of size are the libraries of the New York Academy of Medicine (92,000 volumes), the Medical Society of the County of Kings, Brooklyn, N. Y. (65,000), the Medical Department of the John Crerar Library, Chicago (53,000), the Lane Medical Library of Stanford University, San Francisco (40,000), the Boston Medical Library (39,723 volumes, 55,386 pamphlets), the Library of the Rhode Island Medical Society (25,000), the Library of the Medical and Chirurgical Faculty of Maryland (20,000), and the St. Louis Medical Library (13,800).

In 1898, Dr. Charles D. Spivak made a tabulation of 120 medical libraries in the United States, of which 67 were medical libraries proper, 45 medical departments in general libraries, 6 pharmaceutical, 1 medicolegal and 1 veterinary. Of these New York State had 29, Massachusetts 19, Illinois and Pennsylvania 10, Ohio 9, Louisiana and Michigan 4. Six years later (1904), Dr. Albert T. Huntington was able to make a tabulation of 215 American medical libraries, containing 1,023,295 volumes *in toto*, and of these 164 were medical, 15 homeopathic, 5 eclectic, 17 pharmaceutical, 9 dental, and 5 veterinary. The list of libraries subjoined, which is confined to purely medical libraries all over the world, indicates 167 medical libraries in the United States as against 118 in Europe. The reason for the large increase in medical libraries in the United States is to be sought in the medical library movement inaugurated by Billings, in the fostering of the movement by the Medical Library Association, and in the generous donations made to medical libraries by public spirited physicians. As a rule, the American physician, whose ambitions and enterprises are practical, seldom cares to make a large private collection, and, if he does, usually bequeaths it to some general medical library. In Germany, on the other hand, many extensive collections of medical books are buried in the great university libraries, and it is an absolute necessity for a physician who devotes his life to original investigation to have a good working collection of his own, as is plain from the numerous sale-catalogues of such collections which appear from time to time. The American collector, such as Weir Mitchell, Kelly, or Jacobs, is more apt to go in for historical *rarissimi* than to accumulate files of periodicals or huge general collections of physiology, pathology, natural history, etc. Many medical libraries have acquired a distinguished status through the donation or purchase of valuable private collections. The Radcliffe Camera in the Bodleian at Oxford, the Senckenberg foundation at Frankfort on the Main, William Hunter's collection in the University of Glasgow, the Gross, Lewis, and Weir Mitchell collections in the Library of the College of Physicians of Philadelphia, Nicholas Senn's donation of the libraries of Baum and Du Bois Reymond to the Newberry Library of Chicago, the Pagel collection in the Library of the Washington University Medical School, St. Louis, the acquisition of the private libraries

of Rudolf Virchow and Oskar Lassar by the Berlin Medical Society, and Dr. Howard A. Kelly's recent donation of his medical library to the Johns Hopkins Hospital, are each an example for public spirited physicians of the future. The valuable library of the late Dr. J. F. Payne, rich in historical treasures, which Osler, Jacobs, and Dock sought to obtain for the Johns Hopkins Medical School, was mysteriously knocked down to an unknown purchaser for £2,300 (the second bid) at London in July, 1911.

Medical library associations are usually cooperative book clubs, in the first instance, which become eventually merged into medical libraries proper. Such an association, for instance, was founded by Daniel Drake in 1851 in aid of building up a medical library for the city of Cincinnati, but it apparently came to nothing. On May 2, 1898, the Medical Library Association of the United States and Canada held its first meeting in the editorial rooms of its first president, Dr. George M. Gould, in Philadelphia, the object of this society being to further the cause of medical libraries by bringing medical librarians together at annual meetings. Among the objects proposed by Dr. Gould were the exchange of library duplicates, the securing of libraries of retiring or deceased physicians, as also of special endowments for medical libraries, a conspectus of rare books and auction sales, and the supplying of abstracts, translations, and special information. The first official and literary organ of the Association was the periodical "Medical Libraries" (Denver, 1898–1902), the publication and editorial management of which was due to the self-sacrificing labors and public spirit of Dr. Charles D. Spivak. This was succeeded by the short-lived Bulletin of the Association of Medical Librarians (Baltimore, 1902), which was followed by the Medical Library and Historical Journal (Brooklyn, 1903–7), edited by Dr. Albert T. Huntington. The present organ is the Bulletin of the Medical Library Association (Baltimore), founded July, 1911, and still current. It is edited by Dr. John Ruhräh and Miss Marcia C. Noyes, the Librarian of the Medical and Chirurgical Faculty of Maryland, who also has charge of the book exchange, established at Philadelphia on December 1, 1899, and removed to Baltimore in October, 1900.

Organization, Administration, and Classification.—Medical libraries usually grow from some private collection donated *en bloc* to start with, or by slow accretion, the nucleus in this case being ordinarily some small group of books belonging to a hospital, medical society, or book club. The best plan for building up a small collection is what has been styled the "concentric." Imagine the nuclear collection to be the center of a series of concentric circles, the continuous radii of which form sectors representing anatomy, physiology, surgery, obstetrics, and the other medical disciplines and specialties, as also collateral subjects like biography, history, periodicals, etc. Lists of desiderata, corresponding with these imaginary sectors can be made, with lines of demarcation, corresponding with the circumferences of our imaginary system of circles, determining the status of the books listed as actual or prospective "values." Those nearest the center, the books immediately wanted, would be the first to be considered. At the outer circumference, the last on each list, would probably be the rare editions and other bibliographical curiosities which now have such prohibitive prices that their purchase, in a small library, may be postponed indefinitely. What books are actually to be purchased, apart from gifts and other complimentary acquisitions, will depend upon the physicians who use the library, and the funds to be raised for its maintenanace will naturally depend upon the extent of their interest in medical literature and, here and there, upon a certain local pride. In a prosperous town, distant from the larger medical libraries, a good working collection might be easily built up on the basis of subscriptions from the members of a medical society or from hospital physicians and others interested in the movement. As there is nothing that physicians are so glad to get rid of as useless office impedimenta, liberal donations of discarded files of periodicals and out-of-date editions should be forthcoming and all duplicates acquired should be kept on hand for exchange purposes. Assuming the collection to be started and properly housed in some room connected with a medical society or hospital, a physician of literary tastes should be selected as honorary librarian and, if there is sufficient business, an actual librarian, preferably a graduate of some library school, should be appointed, assuming that a salary can be paid, and that desk, stationery, telephone, and typewriter can be provided. The librarian's first duty will be to shelve and classify the collection. In a small library, this is a simple task. The books should be arranged in alphabetical order under a few grand divisions, such as biography, periodicals, internal medicine, obstetrics, ophthalmology, etc., and a card catalogue should be made by authors, and, if there are enough books, by subjects, the cards giving the location of the books on the shelves. The next duty of the librarian will be to arrange for recording the issues and returns of books loaned and to increase the collection in every way possible. The most valuable part of any medical library of size is its collection of periodicals, the working literature of medicine. A special study should be made of these, using the check lists of the Surgeon General's Office as a guide (Index Catalogue, 1st series, X, 723–935, 2 series XII, 839–978). The duplicate files of periodicals in the Surgeon General's Library have been accessible to date for all medical librarians who are willing to visit Washington to make their own personal selection and pay for the transportation of the same, but in the nature of things, no catalogues or check lists of duplicates can be expected or required of the government as an obligation. It is suggested that, where a particular periodical is desired by a certain group of physicians for their local medical library, it could be easily obtained, either as to complete files or current subscription, by the simple and economical expedient of clubbing together.

When a medical library has attained to large dimensions, 100,000 volumes more or less, it will require a separate building, the librarian will need assistants and messengers, and the problem of arrangement and classification will have become more complex. The question of suitable housing, heating, ventilation, lighting, and shelving can best be studied by visiting the larger medical libraries at Boston, Philadelphia, New York, and Washington, in connection with the architectural plans. In general, it is best that, in the central hall or reading room, the light should be shed from above downward by means of large upper windows, lateral glass roofing or electricity, and if there are many reading desks, they should be provided with separate lights. If the shelving is in several stories, the books most needed, usually the periodicals, reference books and current literature of importance, should be on the first floor, and those seldom called for in the higher alcoves. In the book stacks of the Surgeon General's Library, the arrangement is briefly: First Floor: periodicals, proceedings and transactions, dictionaries, encyclopedias, elephantines, and volumes in folio. Second Floor: medical literature classified by subjects. Third Floor: Miscellaneous unclassified literature, public health reports and public documents, boxed unbound pamphlets, non-medical (scientific and other) periodicals and transactions (including chemistry, pharmacy, dentistry, and veterinary medicine), Chinese and Japanese books, incunabula, and volumes in MS. The classification of books in the Surgeon General's Library will be found in the Bulletin of the Association of Medical Librarians, Baltimore, 1902, I,

No. 2, 70–83. It is very simple, consisting of Anatomy, Anthropology, Biography, Biology, Chemistry and Toxicology, Children, Circulatory System, Diathetic and Specific Infectious Diseases, Diagnosis, Digestive System, Ductless Glands, Ear, Eye, Genitourinary System, Geography and Climatology, Gynecology, Homeopathy, Hygiene and State Medicine, Lymphatics, Medicine (Clinical, History, etc.), Miscellanies, Nervous System, Obstetrics, Osseous System, Pathology, Physiology, Respiratory System, Skin, Surgery, Teeth and Dentistry, Therapeutics, Veterinary Medicine, with the necessary subdivisions. In this Library, the location of the books on the shelves is indicated on the back of the author cards, and on the accession tickets pasted in each book, by a formula giving the floor (A, B, C), number of alcove, number of shelf and partition in the same, *e.g.* A $\frac{27}{5-2}$ indicates that the given book is to be found in the second partition of the fifth shelf in the twenty-seventh alcove on the first floor. For a more elaborated classification, that prepared for the College of Physicians of Philadelphia by its librarian, Mr. Charles Perry Fisher, may be consulted (see Bull. Ass. Med. Libr., 1902, I, No. 2, 46–70). If the decimal classification of Melvil Dewey is desired, Dewey's Decimal Classification (Library Bureau, 1899, pp. 610–619) or the classification of medical literature (Class R) in the Library of Congress (1910, obtainable from the Superintendent of Documents) will be of use.

It is desirable to give all books over one hundred pages an accession numeral, so that the number of volumes in a library can be ascertained at any time, and, to the same end, a careful count of the pamphlets, theses, MS, charts, portraits, etc., should be kept as they come in.

The periodical literature of medicine has been indexed by subjects in the Index Catalogue and Index Medicus; by authors, for the eighteenth and early nineteenth century literature, in Callisen's Medicinisches Schriftsteller-Lexicon (1830–45), and, for the fundamental sciences from 1800 to 1900, in the Royal Society's "Catalogue of Scientific Papers" (1867–1914), which is now in process of completion.

Medical Libraries of the World

With Name of Librarian and Number of Volumes and Pamphlets.

Aberdeen, Scotland.—Library of the Aberdeen Medico-Chirurgical Society (1789). Mr. P. Howie. 8,000+ v.

Albany, New York.—New York State Medical Library (1891). Miss Frances K. Ray. 13,196 v.

Algiers.—Bibliothèque de l'Institut Pasteur d'Algérie.

Amsterdam, Holland.—Bibliothek van de Nederlandsche Maatschappij tot Bevordering der Geneeskunst. [Library of the Netherlands Medical Society.] Dr. C. E. Daniels. 25,665 v.

Ann Arbor, Michigan.—Library of the Medical Department, University of Michigan (1854). Mr. Theodore W. Koch. 25,000 v.

Antwerp, Belgium.—Library of the Antwerp Medical Society. Dr. Edward d'Haenens. 3,150 v.

Atlanta, Georgia.—Library of the Atlanta College of Physicians and Surgeons (1898). Miss Cornelia Cunningham. 2,500 v.

Library of the Atlanta Medical Association. Dr. H. F. Harris. 2,000 v.

Library, Atlanta School of Medicine (1905). Mrs. M. H. Smith. 1,500 v.

Augusta, Georgia.—Library of the Medical Department, University of Georgia (1835). Mrs. G. C. Bentley. 5,000 v.

Bahia, Brazil.—Bibliotheca da Faculdade de medicina (1808). Sr. P. Guimaraes. 13,595 v.

Baltimore, Maryland.—Enoch Pratt Free Library. Medical Department (1882). Dr. Bernard C. Steiner. 1,500 v.

Johns Hopkins Hospital Library (1889). Miss Minnie W. Blogg. 12,000 v.

Johns Hopkins Medical School Library (1876). Dr. M. L. Raney. 12,233 v.

Library of the College of Physicians and Surgeons (1905). Miss Lucy G. Blake. 1,340 v.

Library of the Medical and Chirurgical Faculty of Maryland (1830). Miss Marcia C. Noyes. 23,000 v.

Library of the University of Maryland, Faculty of Physic (1813). Mr. Samuel Want. 12,500 v.

Beirut, Syria.—Medical Library of the Syrian Protestant College (1863, 1866). Rev. H. Porter. 1,800 v.

Belfast, Ireland.—Library of the Ulster Medical Society (1862). Dr. W. L. Storey. 2,000 v.

Berlin, Germany.—Bibliothek der Berliner Medizinischen Gesellschaft [Library of the Berlin Medical Society] (1860). Dr. Hans Kohn. 23,579 v., 22,763 p.

Bibliothek der Deutschen Gesellschaft fur Chirurgie [Library of the German Surgical Society] (1872). Dr. Herman Fischer. 36,000 v.

Bibliothek des Instituts der Nahrungsmittelkunde. [Library of the Institute for the Study of Food Products.] Prof. Bongert. 16,000 v.

Bibliothek des Königl. Instituts fur Infectionskrankheiten (1891). [Library of the Infectious Diseases Institute.] Dr. Sotz. 39,740 v.

Bibliothek des Kaiserlichen Gesundheitsamts [Library of the Imperial Public Health Department] (1876). Dr. A. Würzburg. 70,700 v., 33,300 p.

Bibliothek der Kaiser-Wilhelms-Akademie fur das militararztliche Bildungswesen [Library of the Kaiser Wilhelm Academy] (1795). Dr. Kuntze. 69,000 v.

Bibliothek des Vereins fur innere Medizin [Library of the Society of Internal Medicine.] Dr. Max Meyer. 10,000 v.

Bern, Switzerland.—Bibliothek des Instituts zur Erforschung der Infectionskrankheiten (1896). [Library of the Institute for Investigation of Infectious Diseases.] Dr. Schürmann. 1,600 v.

Birmingham, England.—Library of the Birmingham Medical Institute (1874). Mr. T. G. Johnson. 14,928 v.

Bordeaux, France.—Bibliothèque de la Société de médecine et de chirurgie (1798). M. J. Méneau. 10,400 v.

Boston, Massachusetts.—Boston City Hospital Medical Library (1891). Dr. John H. McCollom. 3,040 v.

Boston Medical Library (1875). Dr. John W. Farlow. 39,723 v. 55,386 p., 34,000 period.

Boston University Medical Library (1873). Dr. Anna T. Lovering. 5,347 v.

Library of the Harvard Medical School (1782). Miss Sarah Ripley Bartlett. 23,000 v.

Library State Board of Health (1869). Dr. Mark W. Richardson. 3,500 v.

Library of Tufts College Medical School (1893). Miss L. A. Mayo. 3,000 v.

Medical Department, Boston Athenaeum (1807). Mr. Charles K. Bolton. 1,500 v.

Medical Department, Boston Public Library (1852). Mr. Horace G. Wadlen. 20,235 v.

Treadwell Library of the Massachusetts General Hospital (1847; Treadwell bequest 1858). Mrs. Grace W. Myers 8,345 v.

Boulder, Colorado.—Medical Department University of Colorado Library (1885). Mr. C. Henry Smith. 2,880 v.

Brighton, England.—Library of the Brighton and Sussex Medico-Chirurgical Society (1847). Dr. R. J. Ryle. 4,000 v.

Bristol, England.—Bristol Medical Library (includes Libraries of Bristol Medico-Chirurgical Society. 11,390 v. and Faculty of Medicine (1874). Mr. C. King Rudge. 21,630 v.

Brooklyn, New York.—Library of the Medical Society of the County of Kings (1845). Dr. Albert T. Huntington. 70,000 v.

Brunswick, Maine.—Library of the Medical School of Maine (1820). Mr. George T. Little. 5,000 v.

Brussels, Belgium.—Bibliothèque de l'Académie royale de médecine de Belgique (1841). Mr. Henri Beckers. 100,000 v.

Bibliothèque de l'Ecole de médecine tropicale de l'Etat (1906).

Bibliothèque de l'Institut Solvay de physiologie (1894). M. J. Van Calck. 2,700 v.

Budapest, Hungary.—Library of the Royal Medical Society of Budapest. Dr. Rudolphe Temesvary. 18,661 v.

Buffalo, New York.—Medical Department Grosvenor Library (1859). Mr. E. P. Van Duzee. 2,600 v.

University of Buffalo Medical Library (1895). Dr. Irving P. Lyon. 9,656 v.

Burlington, Vermont.—Medical Library of the University of Vermont. Miss Helen B. Shattuck. 3,000 v.

Caen, France.—Bibliothèque de la Société de médecine de Caen (1798). M. D. Bonnet. 1,960 v. and p.

Cairo, Egypt.—Bibliothèque de la Société khédiviale de médecine (1898). Dr. Christophides. 2,000 v.

Calcutta, India.—Library of the Medical College of Bengal Ram Chandra Mookerjee. 20,000 v.

Cambridge, Massachusetts.—Library of Harvard University, Medical Department. Mr. W. H. Tillinghast. 2,169 v.

Chapel Hill, North Carolina.—Medical Department, Library

of University of North Carolina (1795). Mr. L. R. Wilson. 3,500 v.

CHARLESTON, SOUTH CAROLINA.—Library of the Medical Society of South Carolina (1891). Privican Whaley. 3,000 v.

CHELTENHAM, ENGLAND.—Cheltenham Medical Library. Dr. J. Rupert Collins. 2,390 v.

CHICAGO, ILLINOIS.—Department of the Medical Sciences of The John Crerar Library (1906). J. Christian Bay. 64,000 v.

Hahnemann Medical College Library (1860). Dr. W. H. Wilson. 2,000 v.

Library of the American Medical Association. 2,500 v.

Library of Northwestern University Medical School (1898). Dr. Walter H. Buhlig. 6,778 v., 8,941 p.

Quine Library, College of Medicine, University of Illinois (1896). Miss Meta M. Loomis. 13,896 v.

Rush Medical College Library (1899). Miss C. A. MacCauliff. 19,522 v.

CINCINNATI, OHIO.—Cincinnati Hospital Library (1870). Dr. E. W. Mitchell. 18,958 v.

Cincinnati Public Library, Medical Department (1871). A. W. Whelpley. 10,000 v.

Eclectic Medical College Library (1845). Dr. J. K. Scudder. 2,000 v.

Library of the Academy of Medicine of Cincinnati. Dr. Archibald I. Carson. 3,500 v.

Library of the Ohio-Miami Medical College. Miss Frances Currie. 2,730 v.

Mussey Medical and Scientific Library (1870). Mr. N. D. C. Hodges. 6,034 v.

CLEVELAND, OHIO.—Cleveland-Pulte Medical College Library (1851). Mr. A. M. Davis. 1,000 v.

Library of the Cleveland Medical Library Association (1894). Mrs. S. M. Harding. 19,158 v.

Western Reserve University Medical Library. Dr. Torald Sollmann. 3,000 v.

CLIFTON SPRINGS, NEW YORK.—Medical Library of Clifton Springs Sanitarium (1914). Miss Maud M. Weston. 1,000 v.

COLUMBIA, MISSOURI.—Medical Library, University of Missouri (1873). Mr. Henry O. Severance. 5,555 v.

COLUMBIA, SOUTH CAROLINA.—Columbia Medical Library (1913). Dr. H. W. Rice.

COLUMBUS, OHIO.—Library of Starling-Ohio Medical College (1877). Mr. W. M. Mutchmore. 5,000 v.

COLOGNE, GERMANY.—Bibliothek der Cölner Akademie für praktische Medizin (1904). [Library of the Cologne Academy of Practical Medicine.] 12,000 v.

COLORADO SPRINGS, COLORADO.—El Paso County Medical Society Library. Coburn Library (1900). Mr. M. D. Ormes. 3,000 v.

CONCORD, NEW HAMPSHIRE.—Medical Department, New Hampshire State Library (1895). Mr. Arthur H. Chase. 12,000 v.

COPENHAGEN, DENMARK.—Library of the Copenhagen Medical Society. Dr. Joergen Moeller. 8,193 v.

Library of the General Hospital. Dr. Joergen Moeller. 4,830 v.

DANBURY, CONNECTICUT.—Wile Medical Library. Mr. M. L. Rogers. 926 v.

DANVERS, MASSACHUSETTS.—Library of the Danvers Lunatic Hospital (1878). Mr. C. W. Page. 600 v.

DENVER, COLORADO.—Library of the Medical Society of the City and County of Denver (1893). Dr. A. J. Markley. 15,000 v.

DETROIT, MICHIGAN.—Library of the Wayne County Medical Society (1910). Miss Jane A. White. 10,000 v.

DRESDEN.—Bibliothek der Gesellschaft für Naturund Heilkunde (1819). [Library of Society of Natural and Medical Sciences.] 5,000 v.

DUBLIN, IRELAND.—Library of the Royal College of Physicians of Ireland (1713). Mr. Robert Phelps. 15,500.

Library of the Royal College of Surgeons in Ireland (1784). Dr. R. Bolton McCausland. 33,000 v.

DÜSSELDORF, GERMANY.—Bibliothek der Akademie für praktische Medizin (1907). [Library of the Academy of Practical Medicine.] Dr. Polentz.

EASTON, PENNSYLVANIA.—Library of the American Academy of Medicine. Miss Elizabeth F. Reed. 5,600 v.

EDINBURGH, SCOTLAND.—Library of Heriot's Hospital (1762). 4,500+ v.

Library of the Pharmaceutical Society of Great Britain (North British Branch). 2,000 v.

Library of the Royal College of Physicians of Edinburgh (1681). Mr. Thomas Harkness Graham. 100,000 v.

Library of the Royal College of Surgeons of Edinburgh (1505). Mr. Harold J. Stiles. 16,000 v.

Library of the Royal Medical Society (1737). Mr. A. P. Ormiston. 30,000 v.

FALL RIVER, MASSACHUSETTS.—Fall River Medical Library (1901). Dr. George L. Richards. 1,200 v.

FARGO, NORTH DAKOTA.—Cass County Medical Library. Dr. C. N. Callander.

FLORENCE, ITALY.—Biblioteca Medica nell'Arcispedale di Santa Maria Nova (1670). [Medical Library of Reale Instituto di studi superiori.] G. Dreyer. 40,000 v., 15,500 p.

FRANKFURT A. M., GERMANY.—Bibliothek des neurologischen Instituts. [Library of the Neurological Institute.] 6,000 v.

Senkenbergische Bibliothek (1763). [Senckenberg Library.] Dr. W. Rauschenberger. 92,241 v.

GALVESTON, TEXAS.—Library of the Medical Department of the University of Texas (1893). Miss Libel L. Hibbs. 8,492 v.

GAMAMS, WEST AFRICA.—Bibliothek des Kaiserlichen bakteriologischen Instituts für Deutch Südwest Afrika (1897). [Library of the Imperial Bacteriological Institute of German West Africa.] 3,000 v.

GLASGOW, SCOTLAND.—Library of the Royal Faculty of Physicians and Surgeons (1698). Dr. Alexander Duncan. 60,000 v. and p.

HANOVER, NEW HAMPSHIRE.—Library of the Medical Department of Dartmouth College (1769). Mr. C. C. Stewart. 8,000 v.

HANOVER, PENNSYLVANIA.—Hanover Public Library, Medical Department. Miss Mabel B. Champlin. 241 v.

HARRISBURG, PENNSYLVANIA.—Library of Harrisburg Academy of Medicine (1896). Dr. C. R. Phillips. 3,300 v.

HARTFORD, CONNECTICUT.—Library of the Hartford Medical Society (1873). Dr. Walter R. Steiner. 5,500 v.

HASTINGS, ENGLAND.—Library of the East Sussex Medico-Chirurgical Society. Dr. Rupert Stanley. 3,120 v.

HAVANA, CUBA.—Biblioteca de la Academia de ciencias medicas, fisicas y naturales de la Habana (1861). [Library of the Academy of Medical Physical and Natural Sciences.] Dr. Leonel Plasencia. 50,000 v.

Biblioteca de Facultad de medicina y farmacia de Universidad de la Habana. [Library of the School of Medicine of the National University] (1728). Dr. Jose A. Valdes Anciano. 4,925 v.

HELSINGFORS, FINLAND.—Library of the Medical Society. (Finska Läkaresällskapet, 1835). Dr. L. Fagerlund. 16,000 v.

INDIANAPOLIS, INDIANA.—Haymond Clark Library (1879). 4,500 v.

Indianapolis Public Library, Medical Department (1898). Miss Eliza G. Browning. 11,075 v.

IOWA CITY, IOWA.—Medical Library of Iowa State University. Miss Jennie E. Roberts. 6,800 v.

JACKSONVILLE, ILLINOIS.—Library of the Morgan County Medical Society (1872). Miss Ella B. Lawrence. 2,643 v.

JERSEY, CHANNEL ISLANDS.—Library of the Jersey Medical Society. Dr. Herbert C. Major. 500 v.

JERSEY CITY, NEW JERSEY.—Jersey City Public Library, Medical Department (1889). Miss Esther E. Burdick. 2,700 v.

KANSAS CITY, MISSOURI.—Kansas City Medical Library Club (1912). Mrs. Rose M. Hibbard. 2,000 v.

KASAN, RUSSIA.—Library of the Society of Neurology and Psychiatry. [Obshchestvo nevropatologov ipsichiatrov (1892). 2,900 v.

Library of the Medical Society. [Obshchestvo Vracheĭ.] 9,700 v.

KHARKHOV, RUSSIA.—Library of the Society of Scientific Medicine and Hygiene (1879). 4,000 v.

KHARTOUM, SOUDAN (AFRICA).—Library of the Wellcome Tropical Research Laboratories (1903). 1,230 v.

KINGSTON, ONTARIO, CANADA.—Queen's Medical Library. A. R. B. Williamson. 2,500 v.

LANSING, MICHIGAN.—Library of the State Board of Health (1873). Dr. Victor C. Vaughan. 10,673 v.

LEEDS, ENGLAND.—Library of the Leeds and West Riding Medico-Chirurgical Society and School of Medicine. Dr. A. S. F. Grünbaum. 9,091 v.

LEIPZIG, GERMANY.—Bibliothek der Deutschen Gesellschaft für Geschichte der Medizin und der Naturwissenschaften (1901). [Library of the German Society of History of Medicine and Natural Sciences.] Prof. K. Sudhoff. 500 + v.

LIVERPOOL, ENGLAND.—Library of the Liverpool Medical Institution (1779). Mr. William Jones. 14,000 v.

LONDON, ENGLAND.—Library of the British Medical Association (1832). Mr. Spencer Honeyman. 40,000 v.

Library of the British Museum (1753). Mr. A. W. K. Miller. [2,000,000 + v., 56,000 Ms., many of which are medical].

Library of the Charing Cross Hospital Medical School (1831). 5,000 v.

Library of Kings College Hospital Medical School (1850). Mr. Clifton Kelway. 2,000 v.

Library of London Hospital Medical College (1740). Dr. William Wright. 5,000 v.

Library of London (Royal Free Hospital) School of Medicine for Women. Miss Gadney. 2,200 v.
Library of London School of Clinical Medicine (1906). Dr. J. Cantlie. 2,000 v.
Library of London School of Tropical Medicine. 800 v.
Library of the Medical Society of London (1773). Mr. George Bethel. 25,000 v.
Library of the Medico-Psychological Association of Great Britain and Ireland (1841). Mr. George Bethel. 3,500 v.
Library of the Middlesex Hospital Medical School (1835). Mr. M. Bazire. 5,000 v.
Library of the Obstetrical Society of London (1859). Miss Agnes Hannam. 5,300 v.
Library of the Ophthalmological Society of the United Kingdom (1880). Mr. George Bethel. 5,000 v.
Library of the Pharmaceutical Society of Great Britain (1841). Mr. J. W. Knapman. 14,000 v. and p.
Library of the Royal Army Medical College. 6,000 v.
Library of the Royal College of Physicians of London (1525). Dr. Norman Moore. 26,000 v.
Library of the Royal College of Surgeons of England (1800). Mr. Victor G. Plarr. 60,000 v.
Library of the Royal London Ophthalmic Hospital (1804). Mr. R. A. Greeves. 1,900 v.
Library of the Royal Sanitary Institute and Parkes Museum (1876). Mr. E. White Wallis. 10,000 v.
Library of the Royal Society of Medicine (1834). Mr. C. R. Hewitt. 80,000 v.
Library of St. Bartholomew's Hospital College (1422). Mr. Alfred Coughtrey. 16,500 v. and p.
Library of the St. George's Hospital Medical School (1752). Mr. A. Lowe. 5,000 v.
Library of St. Mary's Hospital Medical School (1850). Mr. F. Nanfan. 4,000 v.
Library of St. Thomas's Hospital Medical School (1207). Mr. George Rendle. 7,350 v. and p.
Library of the Tropical Diseases Bureau (1908). Mr. R. L. Sheppard. 360 v., 1,500 p.
Library of University College Hospital Medical School. Mr. L. Rhys Thomas. 12,500 v.
Library of the West London Medico-Chirurgical Society (1882). 1,500 v.
Library of the Westminster Hospital Medical School (1834). Dr. E. B. Hulbert. 1,750 v.
The Wills Library, Guy's Hospital (1777). Mr. William Wale. 8,000 v.

Los Angeles, California.—Barlow Medical Library (1906). Miss Jessie A. Wier. 4,570 v.
Los Angeles County Hospital Library (1914). Dr. C. H. Whitman.

Louisville, Kentucky.—Jefferson County Medical Library (1906). Miss Anna L. Goff. 5,700 v.
Louisville Free Public Library, Medical Department (1905). Mr. George T. Settle. 900 v.

Lyons, France.—Bibliothèque de la Société de médicine de Lyon (1789). 3,000 v.

Madras, India.—Library of the Madras Medical College (1835). S. Chidambara Pellay. 5,426 v.

Madrid, Spain.—Biblioteca de la Real Academia de medicina de Madrid. [Library of the Academy of Medicine of Madrid.] Sr. A. Fernandez-Caro y Nouvilas. 8,000 v.
Biblioteca de la Universidad central; Facultad de medicina. [Library of the Faculty of Medicine, Central University.] Sr. M. Gesta y Leceta. 40,031 v.

Manchester, England.—Conjoint Library of the Manchester Medical Society (1834) and the Faculty of Medicine in the University. Mr. A. F. C. Davey. 42,000 v.
Library of the Manchester Royal Infirmary (1752). Dr. F. E. Tylecote. 6,200 v.

Manila, Philippine Islands.—Library, Bureau of Science. Miss Mary Polk. 23,308 v.

Medfield, Massachusetts.—Library of the Medfield Asylum (1896). Dr. E. H. French. 81 v.

Melbourne, Australia.—Medical School Library, University of Melbourne. Mr. Frank Gladish. 11,434 v.

Memphis, Tennessee.—Library of the College of Medicine. Mrs. Belle W. Turner. 5,000 v.

Milford, Massachusetts.—Library of the Thurber Medical Association (1858). Dr. J. M. French. 200 v.

Milwaukee, Wisconsin.—Library of the Marquette University School of Medicine (1913). Dr. Maurice Henderson. 3,000 v.
Library of the Milwaukee Medical Society. Dr. W. L. LeCron. 8,000 v.

Minneapolis, Minnesota.—Library of the Hennepin County Medical Society (1856). Mrs. Carrie C. Jones. 5,120 v.
Library of the Medical Department of the University of Minnesota (1888). Dr. Thomas G. Lee. 10,000 v.

Mobile, Alabama.—Library, School of Medicine, University of Alabama (1859). Mr. W. L. Cahall. 2,500 v.

Montreal, Canada.—Library of Faculty of Medicine, Montreal (1886). Dr. E. P. Chagon. 5,000 v.
McGill Medical Faculty Library (1823). Miss M. R. Charlton. 35,000 v.

Montgomery, Alabama.—Library of the State Board of Health (1878). W. H. Sanders. 5,000 v.

Munich, Germany.—Bibliothek des Münchener ärztlichen Vereins. [Library of the Munich Medical Society] (1833). Dr. Bernhard Spatz. 27,768 v. 41,250 p.

Nancy, France.—Bibliothèque de la Société de médecine de Nancy (1842). 2,000 v.

Nantes, France.—Bibliothèque de l' École de plein exercise de médecine et de pharmacie (1808). M. R. Aubineau. 25,000 v.

Newark, New Jersey.—Library of the Newark Medical Library Association (1905). Mr. John Cotton Dana. 2,500 v.

Newcastle-upon-Tyne, England.—Library of University of Durham College of Medicine (1851). 5,000 v.

New Haven, Connecticut.—Library of Medical Department, Yale University. Prof. J. C. Schwab.
Library of the New Haven Medical Association (1807). Dr. Gustavus Eliot. 6,000 v.

New Orleans, Louisiana.—Charity Hospital Medical Library (1881). 4,977 v.
Library of the Medical Department, Tulane University of Louisiana (1843). Miss Jane Grey Rogers. 8,500 v.
Library of the Orleans Parish Medical Society (1878). Dr. Howard D. King. 12,000 v.

New York City.—Cornell University Medical College Library (1898). Dr. Élise S. L'Espérance. 8,000 v.
Library of the College of Physicians and Surgeons. Mr. Alfred L. Robert. 9,259 v.
Library of Fordham University School of Medicine (1905). Miss Marion J. James. 3,000 v.
Library of the Health Department (1866). 1,559 v.
Library of the Medico-Legal Society (1872). Mr. Frank G. Lodge, 1,500 v.
Library of the New York Academy of Medicine (1877). Mr. John S. Brownne. 100,000 v., 85,000 p.
Library of the New York Eye & Ear Infirmary (1900). Dr. Henry C. Price. 1,000 v.
Library of the New York Homeopathic Medical College and Hospital (1886). Mr. William Gow. 5,423 v.
Library of the Physicians of the German Hospital (1857). Dr. Hermann G. Klotz. 5,774 v.
Library of the Psychiatric Institute of the New York State Hospitals. 3,000–4,000 v.
Library of the Research Laboratory of the Department of Health (1892). Miss Julia Harding. 1,700 v.
Library of the Rockefeller Institute for Medical Research (1904). Miss Lillia M. D. Trask. 7,000 v.
Mott Memorial Medical and Surgical Library (1867). Dr. J. W. S. Gouley. 3,000 v.
New York Public Library, Medical Department (1895). Mr. E. H. Anderson, Director. 9,000 v.

Northampton, Massachusetts.—Forbes Library, Medical Department (1894). Mr. J. LeRoy Harrison. 5,000 v.

Norwich, New York.—Chenango County Medical Library (1910). Miss N. Louise Ruckteshler. 547 v.

Nottingham, England.—Library of the Nottingham Medico-Chirurgical Society (1828). Mr. Kenneth Black. 1,500 v.

Oakland, California.—Library of the Oakland College of Medicine and Surgery (1902). Dr. E. N. Ewer. 6,000 v.

Odessa, Russia.—Library of the Odessa Jewish Hospital (1891). Boris M. Schaposchnikoff. 1,550 v.

Omaha, Nebraska.—Library of College of Medicine of University of Nebraska (1904). Mrs. A. C. Berry. 6,000 v.
Omaha Public Library, Medical Department (1905). Miss. Edith Tobitt. 3,000 v.

Orange, New Jersey.—William Pierson Memorial Library (1901). Dr. Palmer A. Potter. 2,812 v.

Oxford, England.—Radcliffe Library. [Radcliffe Camera in the Bodleian Library] (1749). Mr. F. Madan. 50,000 v.

Paris, France.—Bibliothèque de l'Académie de médecine (1820). Dr. Wickersheimer. 60,000 v.
Bibliothèque de l'École d'application du service de santé militaire (1850). Dr. P. Busquet. 23,000 v.
Bibliothèque de l'École supérieure de pharmacie. Dr. P. Dorveaux. 50,000 v.
Bibliothèque de la Faculté de médecine de Paris. Dr. F. L. Hahn. 240,000 v., 80,000 p.
Bibliothèque Henri Fenlard. Dr. Louis Wickham. 20,962 v.
Bibliothèque des internes de l'assistance publique centrale. M. André Mesureur. 35,000 v.

Bibliothèque de l'Institut Pasteur. [Medical Library of Pasteur Institute] (1888). M. Raveau. 20,000 v.
Bibliothèque de la Policlinique H. de Rothschild. M. Ch. Mettling. 12,000 v.
Bibliothèque de la Société de médecine de Paris (1796). Dr. Debrigode. 6,000 v.
Bibliothèque de la Société nationale de chirurgie (1843). Prof. A. Broca. 8,000 v.

PHILADELPHIA, PENNSYLVANIA.—Jefferson Medical College Library (1898). Mr. Charles Frankenberger. 5,635 v.
Library of the Academy of Natural Sciences of Pennsylvania (1812). Dr. E. J. Nolan. 3,084 v.
Library of the College of Physicians of Philadelphia (1788). Mr. Charles Perry Fisher. 101,340 v., 89,807 p.
Library of the Department of Research Medicine, University of Pennsylvania. Dr. R. M. Pearce.
Library of Hahnemann Medical College and Hospital of Philadelphia (1850). Dr. Thomas Lindsley Bradford. 15,000 v.
Library of the Medico-Chirurgical College (1907). Dr. A. C. Morgan. 4,500 v.
Library of the Wistar Institute of Anatomy and Biology (1892). Miss Clara N. Perine. 5,000 v.
Library of the Woman's Medical College of Pennsylvania (1850). Miss Henrietta Neuberger. 1,600 v.
Medical Department of the University of Pennsylvania Library (1765). Morris Jastrow. 28,000 v.
Mercantile Library Company, Medical Department (1821). Mr. John Edmunds. 5,000 v.
Pennsylvania Hospital Medical Library (1762). Mr. Milton M. Bergey. 15,000 v.

PITTSBURG, PENNSYLVANIA.—Carnegie Library of Pittsburg, Medical Department (1895). Mr. Harrison W. Craver. 5,000 v.
Library of the Pittsburg Academy of Medicine (1897). Dr. Henry T. Price. 5,500 v.

PLYMOUTH, ENGLAND.—Library of the Plymouth Medical Society (1794). Dr. A. Bertram Soltau. 1,700 v.

PORTLAND, MAINE.—Portland Medical Library (1895, 1911). Miss Marcia A. Libby. 1,040 v.

PORTLAND, OREGON.—R. B. Wilson Library (1893). Dr. John D. MacLaren. 1,860 v.

PORTO ALEGRE, BRAZIL.—Bibliotheca da Faculdade libre de medicina (1899). Sr. D. Ferraz. 3,000 v.

POSEN, GERMANY.—Bibliothek des königlichen hygienischen Institutes (1899). [Library of the Royal Institute of Hygiene.] 800 v.

POTTSVILLE, PENNSYLVANIA.—Schuylkill County Medical Library Association (1912). Dr. Gouverneur H. Boyer. 500 v.

POUGHKEEPSIE, NEW YORK.—Library of the Medical Society of the County of Dutchess (1909). Dr. A. L. Peckham. 2,025 v.

PRAGUE, BOHEMIA.—Bibliothek des deutschen naturwissenschaftlich-medizinischen Vereins für Böhmen (1848). [Library of the German Society of Natural and Medical Sciences of Bohemia.] 8,000 v.
Library of the Bohémian Medical Society. Spolek českých mediků (1868). 22,000 v.

PROVIDENCE, RHODE ISLAND.—Library of Rhode Island Medical Society (1879). Dr. George D. Hersey. 25,000 v.

PUEBLO, COLORADO.—Library of the Pueblo County Medical Society (1896). Dr. A. W. Bulette. 4,558 v.

QUEBEC, CANADA.—Bibliothèque médicale de l'Université Laval (1852). M. P. B. Garneau. 5,229+ v.

READING, ENGLAND.—Library of the Reading Pathological Society (1841). Dr. J. B. Hurry. 3,000 v.

READING, PENNSYLVANIA.—Library of the Berks County Medical Society. Dr. Clara S. Keiser.

RICHMOND, VIRGINIA.—Library of Medical College of Virginia (1900). Dr. E. C. L. Miller. 4,000 v.

RIGA, RUSSIA.—Library of the Society of Russian Physicians (1888). Dr. A. J. Orloff. 2,000+ v.

RIO DE JANEIRO, BRAZIL.—Assistencia a alienados do Rio de Janeiro (1841). Dr. M. Mattos. 4,550 v.
Bibliotheca da Faculdade de medicina, cirurgia e farmacia (1808). Dr. A. Paulino. 36,600 v.
Bibliotheca do Istituto Oswaldo Cruz (1901). Dr. A. Lutz. 25,000 v.
Library of the Medico-legal Institute. Dr. J. de Barros (1856, 1907). 3,000 v.

ROCHESTER, MINNESOTA.—Mayo Clinic Library. Mrs. M. H. Mellish.

ROCHESTER, NEW YORK.—Library of the Rochester Academy of Medicine. Dr. W. M. Brown. 3,500+ v.

ROSEDALE, KANSAS.—Library of School of Medicine, University of Kansas (1905). Sarah E. Stanton. 2,310 v.

ST. LOUIS, MISSOURI.—Library of the St. Louis University School of Medicine (1904). Mr. S. F. Waldeck. 8,000 v.
Library of Washington University Medical School (Reorg. 1910). Miss Helen M. Tiesler. 15,000 v.
St. Louis Medical Library (1899). Dr. Frank J. Lutz. 14,500 v.
St. Louis Public Library, Medical Department (1865). Mr. A. E. Bostwick. 6,386 v.

ST. PAUL, MINNESOTA.—Ramsey County Medical Library (1899). Miss Irene Goette. 10,000 v.

ST. PETERSBURG, RUSSIA.—Library of the Imperial Clinical Institute of the Grand-Duchess Helen Pavlovna. [Imp. Kamer. Institute Velikoj Kn. Jeleny Pavlovny.] Dr. H. C. Aue. 15,000 v.
Library of the Imperial Institute for Experimental Medicine (1891). Dr. V. G. Tsakov. 20,100 v.
Library of the Imperial Military Medical Academy (1798). [Imp. S.-Peterskovyenno-med. Akademiya.] Dr. A. R. Voynic-Sianoženskv. 180,000 v.
Library of the Medical High-School for Women (1897). [Zenskij Medicinskij Institut.] Dr. V. J. Bras. 23,962 v.

SAN FRANCISCO, CALIFORNIA.—Lane Medical Library of Stanford University (1895). Miss Louise Ophüls. 37,667 v.
Library of the Cooper Medical College (1895). Dr. Emmet Rixford. 2,611 v.
Library of the Hahnemann Medical College of the Pacific (1900). Dr. Guy E. Manning. 4,250 v.
Library of the Medical Department, University of California (1898). Dr. Milton B. Lennon. 4,200 v.
San Francisco County Medical Society Library. Dr. L. Eloesser. 4,780 v.

SÃO PAULO, BRAZIL.—Bibliotheca da Escola de pharmacia, odontologia e obstetricia (1898). 2,000 v.

SAVANNAH, GEORGIA.—Library of the Georgia Medical Society (1804). Dr. V. H. Bassett. 3,000 v.
Library of the Municipal Hygienic Laboratory, Board of Sanitary Commissioners (1908). Dr. V. H. Bassett. 1,000 v.

SCRANTON, PENNSYLVANIA.—Lackawanna County Medical Society Library (1909). Dr. J. M. Wainwright. 2,500 v.

SEATTLE, WASHINGTON.—Washington Medical Library Association (1898). Miss Alice B. Johnson. 4,000 v.

SHEFFIELD, ENGLAND.—Sheffield Medico-Chirurgical Society (1869). Dr. D. Burgess. 20,000 v.

SONYEA, NEW YORK.—Medical Library of Craig Colony for Epileptics. 2,800 v.

SPRINGFIELD, MASSACHUSETTS.—City Library (1875). J. C. Dana. 800 v.

STOCKHOLM, SWEDEN.—Bibliotek Kungl. Karolinska medico-kirurgiska Institutet. [Library of the Caroline Medico-Chirurgical Institute] (1815). Dr. Emil Havermann. 41,000 v.
Library of the Association of Swedish Physicians (1808). Svenska Läkaresällskapet. Dr. E. O. Hultgren. 35,000 v.

SYRACUSE, NEW YORK.—Library of the College of Medicine, Syracuse University (1906). Dr. Frank W. Marlow. 9,100 v.

TERRE HAUTE, INDIANA.—Library of the Vigo County Medical Society. (Emeline Fairbanks Memorial.) Mrs. Sallie C. Hughes. 1,373 v.

TOKYO, JAPAN.—Library of the Imperial Japanese Institute for Infectious Diseases (1892). Dr. J. Matsui.
Library of the Tokyo Charity Hospital Medical College. Dr. T. Toriyama. 2,750 v. Japanese, 4,565 v. foreign.

TOLEDO, OHIO.—Library of the Toledo Medical College (1886). 1,200 v.

TOMSK, RUSSIA.—Library of the Society of Naturalists and Physicians (1889). 1,000 v.

TOPEKA, KANSAS.—Stormont Medical Library. Mr. James L. King. 3,595 v.

TORONTO, CANADA.—Library of the Academy of Medicine, Toronto (1907). Miss Louise E. Mason. 6,000 v.
University of Toronto Library, Medical Department (1829). Mr. H. H. Langton. 15,000 v.

TUNIS, AFRICA.—Bibliothèque de l'Institut Pasteur (1894). Mme. G. Dudouet. 2,000 v, 50 period.

TURIN, ITALY.—Biblioteca della R. Accademia dé medicina. Prof. R. Tusari, 60,000 v.

UNIVERSITY, NORTH DAKOTA.—University of North Dakota Library (1883). Mr. Clarence Summer. 2,000 v.

UTICA, NEW YORK.—Utica State Hospital Medical Library (1843). Mr. Rees P. Pyghe. 6,494 v.

VANCOUVER, BRITISH COLUMBIA.—Library of Vancouver Medical Association (1906). Miss Mary M. D. MacCagan. 3,000 v.

VERMILLION, SOUTH DAKOTA.—University of South Dakota Library (1882). Miss Mabel K. Richardson. 1,200 v.

VIENNA, AUSTRIA.—Bibliothek der K. K. Gesellschaft der Aerzte in Wien. [Library of Medical Society of Vienna.] Dr. H. Paschkis. 45,000 v.

WASHINGTON, D. C.—Library, Department of Medicine, George Washington University (1825). Emil Walter. 2,537 v.

Library, Bureau Public Health and Marine Hospital Service (1872). Dr. Paul Preble. 6,000 v.
Library of the Surgeon General's Office (1865). Col. C. C. McCulloch. 220,749 v., 331,802 p.
Library of the U. S. Naval Medical School (1902). Mr. C. R. Eagle. 16,200 v.
WAVERLY, MASSACHUSETTS.—McLean Hospital Medical Library (1887). Miss E. Kathleen Jones. 5,422 v.
WHEELING, WEST VIRGINIA.—Library of the Wheeling Medical Library Association (1896). Dr. Frank LeMoyne Hupp. 3,000 v.
WILKES-BARRE, PENNSYLVANIA.—Luzerne County Medical Society Library (1909). Dr. Lewis H. Taylor. 5,425 v.
WILNA, RUSSIA.—Library of the Imperial Medical Society. [Imp. Vilenskoye Meditsinskoye obshchestvo] (1805). 19,087 v.
WINNIPEG, MANITOBA, CANADA.—Medical Library, College of Physicians and Surgeons of Manitoba (1899). Miss S. D. MacIntyre. 2,000 v.
WORCESTER, MASSACHUSETTS.—Library of the City Hospital (1873). 500 v.
Worcester District Medical Library (1822). Dr. Merrick Lincoln. 9,971 v.

YORK, ENGLAND.—Library of the York Medical Society (1832). Dr. A. B. Northcote. 6,000 v.
YORK, PENNSYLVANIA.—York County Medical Society Library (1900). Dr. I. H. Betz. 3,000 v.

ZARAGOZA, SPAIN.—Biblioteca provincial y universitaria. Seccion de medicina (1884). 11,000 v.
ZÜRICH, SWITZERLAND.—Medizinish-Chirurgische Bibliotheksgesellschaft. [Medico-chirurgical Library Society] (1810). Dr. V. Wirz. 25,000 v.

FIELDING H. GARRISON.

Lice.—*Siphunculata.* An order of insects. The proboscis is armed with recurved hooklets, and contains a hollow extensible sucker formed by the mandibles and maxillæ; eyes without facets; thorax unsegmented; wings absent; legs with hook-like terminal joints suitable for clinging. There are two families: the *Pediculidæ* (containing *Pediculis capitis*, the head louse, *P. corporis* the body-louse, and *Phthirius pubis*, the pubic or crab-louse) and the *Ricinidæ*.

A. S. PEARSE.

Lichen.—The term lichen from λειχήν, the Greek word for moss, is conspicuous in the history of cutaneous medicine. William,[1] writing in 1814, could not determine from the works of Hippocrates the exact significance attached to it by the ancients and concludes by defining lichen as: "An extensive eruption of papulæ, affecting adults, connected with internal disorder, usually terminating in scurf, recurrent, not contagious—the varieties of this eruption are seven."

No condition has been the subject of more misunderstanding and controversy than lichen and its supposed varieties, and what we understand by lichen to-day has been achieved by the slow process of nosological evolution, which is not yet complete. One by one the supposed varieties of lichen have been relegated to other groups or recognized as distinct affections as their nature has become better understood. By most clinicians lichen is now limited to one well-defined disease, which from its flat-top, papular nature, Wilson named lichen planus.[2] The essential features in all eruptions entitled to this generic name are the presence of papules and their chronic course. Some of these conditions in which this papular feature was formerly alone recognized, have on further observation and histological study been found to possess additional distinctive features, such as their association with cutaneous follicles or in certain aberrations of the epidermic structure. In these cases a more distinctive name has been given, such for example as the pityriasis pilaris of Divergie which was the lichen ruber of Hebra and the lichen acuminatus of Kaposi.[3]

LICHEN PLANUS.—The adjective, *planus*, flat, was first used to designate a papular, flat, shiny-topped eruption, possessing well-defined characteristics which entitled it to the dignity of a disease *sui generis*, and representative of the lichen group.

SYMPTOMS.—The disease begins without marked subjective symptoms, and during its whole course, aside from local discomfort, the patient may not be aware of any constitutional disturbance. The first symptom to attract attention is the appearance of the eruption, which usually makes its advent insidiously on the flexor surface of the wrists, in fact, it may be limited to this region; more frequently, during a period of weeks or months it appears on other parts, notably the lower third of the legs, while occasionally, when fully developed it covers nearly the entire cutaneous surface. Sometimes the eruption disappears on the parts first invaded and breaks out on remote areas which in turn likewise subside, to be followed by further extension. The face is seldom involved and the palms and soles in like manner usually enjoy more

FIG. 3730.—Lichen Planus. (Courtesy of Dr. G. W. Wende.)

or less immunity. Again, in some instances its distribution is more generalized although the wrists, forearms, and legs and finally, to a less extent, the abdomen and back bear the brunt of the attack. The eruption may be confluent or in clusters on the forearms and legs while discrete or very sparcely distributed elsewhere. A case now under observation, that of a young man, presented a typical pinkish, flat-topped eruption well marked on the forearms with a few discrete patches on other parts of the body, but confluent on the lips where it was last to disappear. The mucous surface of the cheeks was likewise involved to a moderate extent. In this case the lips alone presented a bluish-violet tint. The eruption seen at a distance at an early stage has a more or less uniform

Fig. 3731.—Lichen Planus.

pinkish or slightly purplish appearance but on close inspection or with the aid of a magnifying lens it is seen to be composed of flat-topped papules, somewhat glistening when viewed at the proper angle. Later the papules develop into small pin-head to pea-sized lesions with a smooth, whitish surface having abrupt or palisade-like margins. The enlargement of the individual papules takes place at the periphery; frequently several lesions merge to form an elevated plaque of several centimeters in area and of irregular outline (see Fig. 3731). When large plaques are formed the peripheral extension is caused by the appearance of new papules rather than by marginal extension of the plaque itself, and the plaque is divided by lines or folds into small squares or polygonal patches, these lines or fissures on the surface indicating the contiguity of papules of which it is composed. Surrounding these plaques there are often isolated papules which become more sparcely distributed as we proceed from the margin of the cluster. When fully developed the base of the papules is of a pink or crimson color becoming purple on dependent parts as on the legs or there may be a blending of this color with deep red. The latter color induced Hebra to call the disease *lichen ruber*, in which a compromise in name was effected by more recent German authors[3] to *lichen ruber planus*. The color of the eruption not only varies in different cases, but also according to the stage and distribution of the disease. Early in its course the light reds predominate while on dependent parts or after the disease has become chronic the deep red, purple, or even sepia-brown prevails. On close examination the flat, glistening surface will be seen to consist of a thin, parchment-like yellowish or whitish surface which does not tend to the formation of easily detached scales and which is sometimes indented in the central area. Wickham called attention to minute red points, the size of a pin point, on the plane, or when confluent, near the line of separation between the papules, which he considers characteristic of the disease.[4] Of the mucous surfaces the buccal cavity seems to be most frequently affected, probably because it is more readily observed; although the genital mucosa in women and the glans penis in men, together with the anal region, may likewise be involved. It is thought by some to extend to the gastrointestinal tract, but on account of the infrequency of postmortem examinations in this disease this is difficult to prove. I have never noticed any symptoms pointing to such involvement.

Itching is the only subjective symptom of constant occurrence and this varies greatly in different cases. At first it is usually of a mild nature, but later, especially if the eruption be extensively distributed and more especially in the aged, it is usually severe, often of a burning character and preventing refreshing sleep. Little disturbance is complained of in the mucous membranes. According to the returns of the American Dermatological Association the statistical frequency of the disease is 0.5566, for in 1907 of 30,181 diseases of the skin reported 168 were lichen planus.

Varieties.—Under the following names various eruptions, possibly representing allied diseases, have from time to time been described: *Lichen simplex*, a mild papular eruption, is now generally regarded as a form of papular eczema. *Lichen verrucosus vel hypertrophicus* is a form of lichen planus most frequently seen on the lower extremities, and consists of a hypertrophied condition of the lesions. It usually indicates a more chronic course than is commonly observed in lichen planus and may persist for years. *Lichen nitidus*—under this term Arndt[5] described a rare disease which according to this observer consists of pin-head sized rounded papules having a pale red or yellowish-brown color which at times differs little from the general color of the skin. The lesions are but slightly raised above the level of the skin and often present a slight depression in the center. The eruption sometimes tends to a linear distribution rather than in clusters as in lichen planus, and the lesions are more frequently discrete. The parts involved are the penis, umbilical region, and the flexor surface of the elbows and wrists. The palms and soles remain free. Still less frequently the eruption becomes more generalized when it tends to a symmetrical distribution. It is of slow evolution and may remain for years. Unlike other forms of lichen no itching or other subjective symptoms are present. *Lichen obtusus corneus*, a name introduced by Brocq[6] in describing an infrequent disease of the skin characterized by somewhat large, hemispherical papules from three to ten millimeters in diameter, most commonly and primarily found on the extremities both upper and lower. At first they are pinkish white in color, later becoming brownish and accompanied by intense itching. The papules remain discrete and their evolution is extremely slow. (For a more complete description see C. J. White, *Jour. Cut. Dis.*, Sept., 1907, p. 385; Hardaway, *Archives of Derm.*, 1880, p. 129; Schamberg and Hirschler, *Jour. Cut. Dis.*, 1906, p. 151.) *Lichen pilaris*, described by Crocker is, I think, synonymous with *lichen spinulosus* of Devergie. Fordyce considers it a distinct form of lichen, but clinically it would be difficult when unaccompanied

by well-defined lichenification to distinguish it from pityriasis rubra pilaris and the keratosis follicularis of Brooke.[7] Lichenification is a term used by Brocq and Jacquet[8] to differentiate a thickened and more or less elevated, reddish, dry, slightly scaly eruption oftentimes limited to a single patch, frequently met with in the axilla or again on other parts of the cutaneous surface. It is characterized by a reddish, elevated patch in which the surface is marked

Fig. 3732.—Lichen Planus Hypertrophicus.

off into small squares, triangles, and quadrilaterals, very itchy and of a chronic course. The eruption has a tendency to recur in the same sites. Clinically, it forms a connecting link between eczema and lichen planus. *Lichen planus morphœicus* or *lichen planus atrophicus* (the white spot disease of Montgomery and Ormsby[9]) is a form of morphœa. *Lichen scrofulosorum*, formerly used to designate a keratopapular disease of the skin, often met with on the abdomen, sides of the chest and thighs, and occurring in clusters. The lesions run a slow course and finally disappear, leaving a slightly yellowish pigmentation. Little itching is present. This condition is now regarded as a tuberculide. A *bullous* or *vesicular form* of lichen planus has been reported by various observers of which Whitfield[10] has collected seventeen cases.

The relation of these eruptions to lichen planus must be regarded as provisional for in many their true nature is still undetermined.

Histopathology.—The first changes noted by Fordyce, in a histological study of the lichen group of skin diseases,[11] takes place in the papillæ, consisting of a dilatation of the vessels and lymph spaces. Following this increased nutrition there is a proliferation of the connective-tissue cells and the papillæ themselves become more prominent. With the foregoing changes the subpapillary layer becomes involved in like manner and a round-celled infiltration ensues. The migration of the leucocytes from the dilated lymph spaces into the epidermis then takes place together with an intracellular edema, resulting in a flattening of the rete pegs and disorganization of the basal-cell layer. With the flattening of the middle rete cells, to which this marked edema gives rise, the granular and corneous strata become hypertrophied, thus completing the characteristic changes found in lichen planus. According to Sabouraud[12] the lesions are due to a proliferation of the mononuclear cells in the papillæ, obliterating the interpapillary processes of the epidermis by pressure, followed by edema of the papillæ sometimes even to the degree of vesiculation. This doubtless accounts for the vesicular or bullous lesions above cited. Acanthosis then takes place in the epidermis followed by intercellular edema, colloid degeneration of the prickle-cells and hyperkeratosis. The central depression frequently observed in the lichen planus lesions is thought by both Crocker and Fordyce to be due to the obliteration of the rete at the point where the hyperkeratosis is most marked, thus forming a funnel-like depression which often corresponds to the orifice of a sweat-duct. The degree of hyperkeratosis largely determines the form of lesion above described. The appendages of the skin remain intact. The histological findings of the mucous membranes resemble those observed in the skin.

Etiology.—The exact cause of lichen is not known. From clinical observation practical deductions have been drawn which serve a valuable purpose in the management of the disease. It is more common in private than in dispensary practice, men and women are about equally affected while it is seldom seen in childhood. I have encountered the disease but twice in children, both in hospital practice; in adults it has usually been attributed to worry, mental strain or overwork and in those of a neurasthenic predisposition. This is in accord with the general opinion concerning this disease and numerous instances are recorded of severe shock (Hyde) or mental over-work (Stelwagon) being followed by lichen planus. It has also been attributed by Walters[13] and Jacquet[8] to traumatism while Hallopeau and Jomier[14] suggest a parasitic origin.

Diagnosis.—In most cases the lesions of lichen planus are characteristic and cannot well be mistaken, but in aberrant or unusual forms, or when modified by treatment some difficulty might arise in making a diagnosis. The dry, smooth, flat-topped papule seen even at an early stage and its slow evolution are sufficient to direct attention to the disease. Later it might be necessary to differentiate it from chronic eczema or psoriasis, but again, only in aberrant forms, such as parapsoriasis, would difficulty arise. It is to be remembered that the scales in lichen are adherent, while in psoriasis they exfoliate. Extensive plaques of psoriasis are less liable to occur on the wrists; the elbows, knees, and scalp being the region of predilection. In psoriasis, too, the lesions extend at the periphery while in lichen, such extension is due to the appearance of new papules. Furthermore, the papules maintain their individuality throughout the course of the disease.

From syphilis with its multiform manifestations a careful consideration of the history, course, and most prominent features will usually serve to differentiate between them. Fortunately it is only during the most active stage of syphilis that the eruption is liable to be mistaken for lichen. In case of doubt repeated Wassermann tests might be employed.

Treatment.—If any of the etiological factors mentioned in the foregoing are found they should as far as

possible be removed, after which the treatment becomes more simple. In general, an out-of-door life with a diet suitable to the needs of the patient, which must naturally vary but be of a simple nature, should be enjoined. Freedom from care and relaxation from mental labor are of importance in many cases. Of internal medication, in my experience, mercury has acted best. The bichloride is usually prescribed in doses varying from gm. 0.002 to 0.006, according to tolerance and the age of the patient. It should not be given to its full physiological limit. Stelwagon prefers arsenic (sod. arsen. sol. 0.165 to 0.2) given in increasing doses (0.33 to 0.4) to the point of tolerance and continued until the disease yields. I would use the drug only in the chronic stage as it may aggravate the eruption during the active or acute stage. Quinine and strychnine are also well spoken of. There is no infallible specific, however, and cases differ in their response to drugs. Internal treatment should be continued for a month or more after the eruption disappears.

As the itching is usually a troublesome symptom, external measures should be adopted for its relief. Topical measures are also of value in causing the eruption to disappear. In the acute stage or when much irritation exists a soothing application is called for, such as the glyceride of tannin, one part, and hamamelis water, three parts, to be applied constantly. *Lotio alba* is likewise used and is a more agreeable though less efficient application. I have found, however, that most cases do better under a stimulating ointment such as the following:

℞.	Liq. carbon. deterg.	10.0
	Hg. ammoniati	4.0
	Adip. lanæ hydr.	75.0
	Petrolati q.s. ad	180.0

M.

Care should be taken that the mercury be finely triturated to an impalpable powder, otherwise harm from irritation may result. The strength of the liquor carbonis detergens may be varied according to the stimulation required, and if necessary, oil of cade may be added to the above. In very chronic or obstinate cases I have often used Wilkinson's ointment with excellent results.

In hypertrophic lichen planus of the lower extremities recourse to the Röntgen rays has been had with favorable results.

The high frequency spark has also apparently favored involution in obstinate cases.

The disease, when untreated, shows little tendency to involution, but under appropriate treatment it usually disappears in from one to three or more months. Relapses during the first two or three months after apparent cure are not uncommon.

William Thomas Corlett.

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Lichen Scrofulosorum.—*Synonyms:* Acne cachecticorum (Hebra, Kaposi), acne scrofulosorum (Colcott Fox), folliculitis scrofulosorum (Unna).

Symptomatology.—Here [illegible] one of the few classic [illegible] stood the test of time. It [illegible] The eruption consists of [illegible] varying in size from a pinhead to an object the size of a pea or bean. They are bright red in color at first, fading gradually [illegible] very little from the surrounding skin in tint. Slight pigmentation is generally left after disappearance. A minute scale forms on the summit of each papule during involution, the desquamation becoming more prominent as the end approaches. The papules occur in groups, circles, or segments of circles with little tendency to coalescence. This grouping is due to their localization about the lanugo hair follicles. The life of each papule varies from a few weeks to five or six months, but the tendency to relapse makes the duration of the disease most uncertain. The site of election is the lower part of the trunk, especially along the flanks, spreading from them in rare cases over the whole body on to the neck, the thighs, and upper arms. As a rule, progress is arrested at the axillæ and groins. There are no subjective symptoms.

Complications may change the appearance of the skin somewhat. The papules show occasionally a central comedo, which may become pustular, as in true acne. These lesions, which have been known to appear on the face, constitute what has been called the acne of cachectic infants. The skin may show evidence of malnutrition in the form of branny scaling between the papules, punctate follicular hemorrhage, and an eczematoid dermatitis, usually pustular, about the genitals. Not infrequently there is an acroasphyxia. In young children the disease may occur on the limbs without attacking the body. Involvement of the extremities is much more common than in adults, but pustulation, on the other hand, is less frequent.

Etiology.—Lichen scrofulosorum is a disease of youth; the youngest recorded case was in a child of eleven months, the oldest in a person of thirty years. Males, at least in German lands which furnish by far the largest number of cases, are more subject to it than females. The chief point in its etiology is the relationship to tuberculosis. According to Austrian statistics, over ninety per cent. occur in the tuberculous. Pulmonary disease is not so common a complication as the condition called scrofulosis, evidenced chiefly by lymphadenitis, bone disease, and tuberculous ulcerations of the skin (scrofuloderma). At times no such lesion is discoverable and there is no family history of tuberculosis.

Of recent years much has been written of this and kindred affections, such as erythema induratum scrofulosorum and the controversy over their etiology has been more or less bitter, not to say personal. One party holds that the appearance of the papules is caused by circulating toxins; the other, that the tubercle bacillus is directly responsible. No one has the hardihood to deny the connection with tuberculosis. Out of a large number of animal inoculations with the tissue, only three have been reported as successful. Jacobi (Congress of German Dermatological Societies, 1892, p. 69) is the only writer who has found the tubercle bacillus in the lesion; Darier, Michelson, and Sack have failed after diligent search. Pelizarri thinks in spite of his single success in inoculation, that the positive findings indicate only a contamination in a soil prepared by the toxins. Hallopeau in 1892 announced that injection of tuberculin produced a perifollicular lesion resembling the lichen, and Schweninger and Buzzi (*Monatshefte f. prakt. Derm.*, vol. xi., 1890, p. 581) have confirmed his observation. Jadassohn and the Vienna school, Kaposi at the head, are convinced that the disease is non-bacillary. Opinion based on later experiments inclines to the theory of local inoculation with sparsely scattered bacilli of feeble virulence.

Histopathology.—The lesion is a perifollicular, productive tuberculosis. The cutis shows an irregular formation of miliary tubercle, consisting of exuded elements in the shape of lymphocytes and plasma cells, epithelioid cells derived from fibroblasts and endothelium, and giant cells of the Langhans type with peripherally arranged nuclei. Coagulation necrosis and caseation are common. The new tissue is non-vascular. There may be made out, at times, even in areas of caseation, a delicate reticulum formed of the remains of the elastic fibers. Epithelial changes are secondary. The epidermis loses its interpapillary projections and becomes flattened. It may be slightly thickened and the horny layer may be lost or be partly detached in the form of a scale.

Diagnosis.—Kaposi characteristically put this matter in a nutshell when he said that the diagnostic points were Hebra's original description and its occurrence in the tuberculous. Papular eczema is not limited to the trunk, as is often the case in lichen; in children the lesions are apt to become vesicular; they are of a deeper red and larger, and itching is intense. Follicular syphiloderms may be localized in much the same way as lichen of the scrofulous, but the papules are larger and involve the cutis more deeply. The common type occurs early in the course of syphilis, and careful search will show evidence of other "secondaries"—lymphadenitis, generalized and indurated, mucous patches, alopecia, etc.

Punctate psoriasis is much more generally distributed than the lichen, it occurs on the face and head, its tint is fiery red at the time of its first appearance, and the scales are thick, white, glistening, and moderately adherent. The papules of lichen do not enlarge; the guttate lesions of psoriasis do. In lichen or keratosis pilaris, while the site may be the same, the extensor surfaces of the upper arms and thighs are almost certain to be affected. The hair is surrounded by a horny plug, which is separated with difficulty

Treatment.—Cod-liver oil, internally, is the remedy most relied upon, but it should be remembered the cutaneous outbreak will follow the course of the general infection. Cod-liver oil was formerly used by inunction. It has been given up because of the objectionable odor. Olive oil or oil of sweet almonds is now used in its place, combined with some antiseptic such as one-half per cent. of menthol or thymol. The general health requires close attention in every instance.

Prognosis is good as regards the individual attack. Otherwise the outlook is that of the intercurrent tuberculosis which is not influenced by the cutaneous outbreak. If the tuberculosis continues, there is always danger of relapse.

James C. Johnston.

Lichenin or moss starch is found in many lichens, especially in Iceland Moss. It is insoluble in water but swells to form a jelly. On the other hand in hot water it is readily soluble and upon allowing the hot concentrated solutions to cool a jelly forms. It gives a yellow color with iodine and yields dextrose by heating with dilute acids. Diastatic enzymes as ptyalin or amylopsin are without action upon lichenin, hence it undergoes but little transformation in the alimentary canal other than that of bacterial digestion.

F. P. U.

Lieberkuehn, Johann Nathaneel.—Born at Berlin, Prussia, September 5, 1711. He received the degree of Doctor of Medicine from the University of Leyden in 1739. After spending some time in London and Paris, for the purpose of becoming better acquainted with the practical side of his profession, he returned to Berlin. From this time onward he appears to have devoted his time and his energies chiefly to the work of perfecting the microscope, and in a lesser degree to anatomical research. "Lieberkuehn's glands," "Lieberkuehn's ampulla" are terms which have found a permanent place in our anatomical text-books. His death occurred Dec. 7, 1758.

Of his published writings the following deserve to receive special mention: "De fabricâ et actione villorum intestinorum tenuium," Leyden, 1745; "Description d'un microscope anatomique," Mém. de l' Acad. Royale des Sciences de Berlin, pour 1745; "Sur les moyens propres à découvrir la construction des viscères," Mém. de l' Acad. Roy. des Sci. de Berlin, pour 1748.

A. H. B.

Leibermeister, Karl.—Born in Ronsdorf, Germany, February 2, 1833. He studied medicine in the universities of Bonn, Würzburg, Greifswald, and Berlin, and received his doctor's degree in 1856. In 1864 he was made Extraordinary Professor of Pathological Anatomy in Tuebingen; from 1865 to 1871 he was Professor of Pathology and Director of the Medical Clinic in the University of Basel, Switzerland; and, from 1871 to the time when he was obliged to resign, he held the same positions in the University of Tuebingen. He died in 1901.

Of Liebermeister's more important published writings the following deserve to receive special mention: "Beiträge zur pathologischen Anatomie und Klinik der Leberkrankheiten," Tuebingen, 1864; "Beobachtungen und Versuche ueber die Anwendung des kalten Wassers bei fieberhaften Krankheiten" (in association with Hagenbach), Leipzig, 1868; "Handbuch der Pathologie und Therapie des Fiebers," Leipzig, 1875; and Vorlesungen ueber espezielle Pathologie und Therapie," five volumes, Leipzig, 1885–1894.

A. H. B.

von Liebig, Baron Justus.—Celebrated German chemist, to whom credit is due for many important modern discoveries in organic and inorganic chemistry. He was born at Darmstadt May 12, 1803, and studied chemistry first at Bonn and then at Erlangen, graduating from the university of the latter city as Ph. D. in 1822. He next went to Paris, where he was admitted to the privileges of the private laboratory of Gaulthier de Claubry, who was at that time Professor of Chemistry at the School of Pharmacy. Then, soon afterward, through the influence of Alexander von Humboldt, he was taken into the laboratory of Gay-Lussac. In 1824 he was appointed Professor Extraordinary of Chemistry at the University of Giessen, being promoted in 1826 to the position of Professor-in-Ordinary. It was in this small town that von Liebig's most important work was accomplished. "His first care was to persuade the Dramstadt government to provide a chemical laboratory in which the students might obtain a proper practical training. This laboratory, unique of its kind at the time, in conjunction with von Liebig's unrivaled gifts as a teacher, soon rendered Giessen the most famous chemical school in the world; men flocked from every country to enjoy its advantages and many of the most accomplished chemists of the nineteenth century had to thank it for their early training." For twenty-eight years von Liebig remained at Giessen, and then he accepted an invitation from the Bavarian government to occupy the regular chair of chemistry at the University of Munich. He died in that city, April 10, 1873.

To enumerate here simply the more important contributions made by von Liebig to our knowledge of chemistry, both organic and inorganic, and to explain even very briefly what great changes were thereby effected in the teaching of physiology, in agricul-

tural methods, and in the preparation of food and pharmaceutical products, would occupy more space than can reasonably be devoted to this subject. Suffice it to say that our indebtedness to von Liebig in these respects is very great.

Of his published writings the following deserve to receive special mention: "Die Chemie in ihrer Anwendung auf Agricultur und Physiologie," 1840 (translated into English soon afterward by Lyon Playfair); "Die Thier-chemie oder die organische Chemie in ihrer Anwendung auf Physiologie und Pathologie," 1842; "Chemische Briefe," 1844; "Chemische Untersuchungen über das Fleisch und seine Zubereitung zum Nahrungsmittel," 1847; "Uber Theorie und Praxis in der Landwirthschaft," 1856; and "Naturwissenschaftliche Briefe über die moderne Landwirthschaft," 1859. In 1832 he founded the *Annalen der Pharmazie*, which later (1840) became the *Annalen der Chemie and Pharmazie*, when Wöhler became joint-editor with himself.

A. H. B.

Lientery, (λειεντερία, λεῖος, smooth; ἔντερον, intestine), diarrhea, or looseness of the bowels in which the food passes rapidly through the digestive tract undigested, and nearly in the same condition as it was when taken into the stomach. The disorder is so called because the food seems to have slipped over a smooth-lined intestine.

The word lientery has been extended to mean the passage of unchanged foods macroscopically recognizable with the stool.

Lientery is frequently encountered in the diarrheas of infants. It appears in two varieties, one in which the stool has a yellowish color, and the other in which the feces are more or less gray or whitish looking. In the latter variety the milk becomes curdled by the action of the gastric juice, but the casein fails to become digested, and the fat remains partly unchanged, due to functional disturbances of the liver and pancreas. The stool therefore appears to consist of clumps of casein intermingled with fat. In the first form the stool is yellowish and sometimes greenish on the surface. The color is due to the bacillus of green diarrhea.

The lienteric stools have a strong odor of fermentation and decomposition. The number of evacuations amounts to four, five, or eight in twenty-four hours. The lientery frequently exists without any further symptoms of dyspepsia or vomiting and is not accompanied by fever. A change in the dietary regime is often the cause of the lienteric attack. Its duration is variable; it may at times become chronic and is then very resistant to treatment.

Lientery in grown individuals occurs occasionally in severe attacks of acute enteritis, but more frequently in chronic affections of the pancreas. A few years ago I had under observation a patient with cirrhosis of the liver and chronic pancreatitis. This patient showed with the bead test a return of all the test substances after passing the alimentary canal. Macroscopically various food articles were visible in the stool. Once we found in the diarrheic feces of this patient well preserved raw oysters, which the patient had swallowed without mastication, the day before.

The *diagnosis* of lientery is made whenever there is a diarrheic movement, in which unchanged food particles can be noticed in profusion with the naked eye.

The *treatment* of acute lientery is identical with that of an attack of acute diarrhea and consists in rest and a very scanty diet consisting of weak tea, broths, rice water, and a raw egg beaten up in bouillon. Hot applications over the abdomen and a small dose of codeine or opium, will also be of benefit.

In the more chronic forms of lientery the principal lesion will have to be dealt with first. For the lientery predigested foods and liquid and semi-fluid nourishment with play a part. Pancreatin or pancreon in five-grain doses will often be of value, especially in cases of chronic pancreatitis. In intestinal dyspepsia accompanied by functional disturbances of the pancreas pancreatin may be combined with taka-diastase, also in five-grain doses. In icteric conditions the adeption of ox-gall to the above medicaments will prove useful.

Max Einhorn.

Lieutaud, Joseph. Born at Aix, in Provence, France, June 21, 1703. He studied medicine and botany in his native city, and in due time was given the degree of Doctor of Medicine. Afterward he visited Montpellier for the purpose of perfecting himself still further in medical knowledge. Upon his return he was appointed one of the attending physicians at the Hôtel-Dieu of Aix, and from that time forward he devoted himself with untiring zeal to the study of anatomy and the observation of individuals affected with disease. In this work he confined himself very strictly to the evidence afforded by his own observation, and was thus enabled soon to publish treatises that possessed the great merit of being original. His book on anatomy, for example, is described by Haller, who flourished from about 1730 to 1770, as being one of the best treatises on this subject that had been written in France up to that period, and indeed the only original treatise since Winslow's book had been published (1732). In 1750, through the intervention of Senac, Lieutaud was chosen Physician of the Royal Infirmary at Versailles; and not long afterward he received the appointment of First Physician to the King. He died Dec. 11, 1780.

Of his published works the following deserve to receive special mention: "Essais anatomiques contenant l'histoire exacte des parties qui composent le corps, de l'homme, avec la manière de dissèquer," Paris, 1742 (3rd edition in 1776–1777); "Précis de la médecine pratique, contenant l'histoire des maladies dans un ordre tiré de leur siège, avec des observations, etc.," Paris, 1759; and "Observation sur un polype en forme de grappe, situé immédiatement audessous du larynx," Mémoires de l' Acad. des Sciences, 1754.

A. H. B.

Life Insurance Medicine.—The incorporation of the "Equitable Society for the Assurance of Lives and Survivorships" in England in 1756 may be regarded as the first step of permanent and properly managed organizations for the insurance of lives. Life insurance in the true sense of the word began in America in 1843, and the business was extended during the next three years through the formation of other companies that have become large and financially strong.

Forms of Life Insurance.—Strictly speaking, all insurance is mutual, as the claims are payable out of the premiums paid by the insured.

Assessment insurance represents the simplest form, each member of the association agreeing to pay an assessment on the death of a member, or at regular intervals in order to keep up a mortuary fund to a certain sum. A number of the societies are undergoing a process of readjustment in order to provide a sufficient fund to meet deficiencies and relieve the cost at the older ages, but without much success so far.

The *level premium*, regular, or "old line" life insurance companies are under the supervision of the State or National authorities and a careful inspection of their financial condition is made annually to insure and compel safety, honesty and good management. The level premium insurance exacts a definite annual payment which is more than sufficient to meet the losses incurred in the earlier years, the ex-

cess being held to take care of the increasing death rate during the later years.

Regular life insurance companies are classified as Mutual, Stock, Mixed, and Industrial.

Mutual.—A mutual life insurance company is one in which there is no capital stock, all of the gains and savings belonging to and going to the policyholders. The policyholders elect the trustees and in this way control the management of the company.

Stock.—A stock company is one having capital stock. The shareholders elect the trustees and control the company. All profits inure to the benefit of the shareholders.

Mixed.—The so-called mixed companies are mutual in essential particulars. They have capital stock owned by shareholders who elect the trustees and so control the management. The shareholders are, however, entitled to only a small percentage of the profits and the balance goes to the benefit of the policyholders.

Industrial.—The industrial companies write both industrial and ordinary insurance. The essential difference between the two forms lies in the method of collection of the premiums, those of the former being payable weekly and collected by agents at the homes of the insured, whereas in the latter the premiums are payable quarterly, semi-annually, or annually at an office of the companies. Naturally, the premiums for industrial policies are higher than those for ordinary policies.

The Application.—The application blank is usually divided into three parts; the application for insurance to be signed by the applicant and witnessed by the agent, the statements to the medical examiner to be signed by the applicant and witnessed by the examiner, and the medical report of the examiner. The statements in the application and to the medical examiner, constitute a declaration which forms the basis for a proposed binding contract. It is imperative to avoid vague and ambiguous terms and to have every question properly, completely, and truthfully answered in order to preserve the legality of the document. The application should not be accepted by the company if any part of the printed matter on the blank has been stricken out. If any change in the written answers is demanded, a line with pen and ink may be drawn through the part to be altered, but the alteration must be attested by the initials of the applicant with the date of attestation. Dashes, ditto marks, and erasures interfere with the legal value of the document.

Under the older laws, applicants for life insurance were required to warrant the truth of all statements. Any misstatement of fact, whether material or not, was held under the law of warranty to give the company legal grounds upon which to refuse payment. No reputable company took advantage of this harsh ruling, however, unless intolerable fraud was practised. Under the present insurance laws in most States, all statements made by the applicant, in the absence of fraud, are deemed to be representations and not warranties. A warranted statement must be true regardless of materiality, while a representation need only be true substantially in all matters material to the risk. Also, according to the present law, no statement can avert or be used in defense of a claim unless it is contained in the written application. If any material statements therein are found to be untrue, the contract, according to its terms, may become null and void.

The Policy.—The policy is the consummation of a contract which stipulates the amount which the holder is to contribute to the common fund and defines his or her rights and privileges. According to a distinct provision in the application blank, the policy does not become operative or binding until it is delivered, accepted, and paid for by the applicant during his continuation in good health. An exception to this provision occurs in the event of the issuance of a binding receipt by the agent in exchange for the premium in cash, according to the terms of which the policy goes into force as soon as the risk is approved by the company.

Laws have been enacted in several of the States requiring the companies to attach to the policy a written or photographed copy of the application and any other instrument referred to in the policy, as a part of the contract.

The term "incontestibility" implies that no objection, after a certain period of time, will be made to the payment of the claim in any event when it becomes due, provided all the premiums have been paid. Practically all policies now written become incontestible in one or two years after the date of issuance. If the company finds, before the policy becomes incontestible, that the insured has been guilty of misrepresentation, it may demand the return of the policy and institute equity proceedings to compel its surrender.

The Premium.—The payment or consideration which a company receives for the obligations incurred in the policy contract is called the premium. The net premium is the sum calculated from a combination of the mortality and interest tables, the process including the principle of averages and the theory of probabilities. The gross premium, that paid by the policyholders, is the amount made up by adding the loading for expenses and contingencies to the net premium.

The Mortality Tables.—It was discovered through the studies of Price and Morgan about the beginning of the nineteenth century that a natural law governs the mortality of the human race, whereby it is possible to determine approximately, in a large group of persons, the number that will die in each year until all are dead. When this law became established the business of life insurance was revolutionized and mathematical calculations superseded crude and primitive guesses of life and death. Various tables were compiled and further developed by the actuaries of America and Great Britain. The American Experience Mortality Table was constructed by Sheppard Homans and is used by practically all American companies in computing their premiums, The Actuaries' or combined Experience Table of Mortality is used in Great Britain and Canada. With the help of these tables, a company knows how much money it must have on hand to meet the payment of each and every policy it has in force without the necessity of adding new members—an essential principle in the construction of a regular life insurance company and the computation of level premiums, as distinguished from assessment societies.

The Interest Rate.—The premiums and the interest earned on the premiums are the only sources of income for the payments due on policies for life insurance. It follows that in computing the premium a certain rate of interest must be assumed and that this rate must be one which the safest securities may be depended upon to earn. The precise rate of interest cannot be determined in advance and should be low, as life insurance contracts run over a long period of years. In other words, invested funds should earn a higher rate than the one assumed for some time to come so as to create a margin of safety.

The Reserve.—Insurance could be effected at lower rates increasing year by year if this plan were convenient and practicable. It has been found, however, eminently more convenient and satisfactory to charge a uniform, level premium throughout life. The disadvantage of insuring with increasing rates is demonstrated by the experience of assessment societies, which shows that men dislike the idea of

rates which gradually become so high as to be prohibitive in advanced age. Furthermore, the changing rates would upset the calculations based on the mortality tables and result in weakening the financial conditions of the companies.

In order to carry out the level premium plan, the net premiums charged in the early years must be greater than are necessary to cover the risks in these years, and the excess accumulated in this way must be reserved for the later years when the advancing ages of the insured will bring a rate of mortality higher than could be met by the net premiums at that time. Technically speaking, the reserve which a company must have on hand to meet future claims as they become due is the difference between the present value of the claims which, under the existing policies, the companies will have to meet and the present value of the payments, under the existing policies, which the company is going to receive. According to law, this reserve fund must be maintained, so that while the fund increases during the early years of the policies there will be just sufficient on hand to pay each and every claim as it becomes due until the last contract will have terminated, without depending upon the taking in of new members.

The Loading. A company cannot be conducted without certain expenses made up of commissions in procuring new business, collection of the premiums and keeping the old policies in force, rents, salaries, medical fees, taxes, and miscellaneous items. Aside from expenses, all possible contingencies must be provided for, such as panics, depression in prices, fall in rate of interest, wars, pestilence, and adverse or oppressive taxation. The allowance for these expenses and contingencies is the difference between the net and the gross premiums.

The Surplus.—An insurance company must have a healthy surplus, so that there can be no question as to its ability to fulfill all contracts, even though they extend many years into the future and unexpected emergencies may arise. If, then, a company could only show assests equal to the legal reserve, it would be on the verge of bankruptcy into which it might be plunged by excessive losses. An additional fund must be maintained to prevent such a misfortune. This fund is variously termed surplus, indivisible surplus, unassigned funds, or contingency reserve. The surplus funds are made up entirely of gains and savings from the following sources: (1) a mortality more favoralbe than that indicated by the tabular rate, and attained only by means of a careful medical selection. (2) Savings derived from the excess in the loading. (3) Savings and gains representing the difference between the interest assumed and the interest earned. (4) Gains from lapses. The amount saved from this source is small, if any. Nearly all policyholders who lapse are in good health, whereas those whose health has become impaired are very apt to cling to their policies. Furthermore, most policies possess a "surrender value" at the end of the third year and thereafter, a certain amount which may be withdrawn if desired. In the event of a default of payment of the premium, if the policyholder does not elect to accept the "surrender value," the amount represented is applied automatically to the purchase of a paid-up policy for extended insurance for a period definitely stated in the policy. The "surrender charge" retained by the companies in these cases is barely adequate for the initial expenses and to reimburse the companies for the adverse selection practised in lapses.

The amount of surplus is determined at the end of each year. If the company is a mutual or mixed one, that part of the surplus not needed for security goes solely to the policyholders in the form of the so-called "dividends" and represents the gain and savings. If the company is a stock corporation, the surplus goes to the shareholders. The stock companies make up for this difference to a large extent by selling insurance at a lower cost, and making up the balance by taking chances with a smaller margin of safety in the loading and in the assumed interest.

The Expectation of Life Table.—This table should not be regarded as one of importance as it is used to a very limited extent in the business of life insurance. It only represents averages and does not take into account the fact that the death rate increases more rapidly than advancing age and that the increase from year to year is neither by the addition of a fixed number nor by multiplication by a fixed multiplier. This fact makes it impossible to calculate the compound interest involved in the cost of insurance. Compound interest must be computed from year to year instead of upon the misleading basis of the average time involved.

Forms of Policies.—A policy for *term* insurance is one payable at death, provided that death occurs within the period specified in the contract. At the end of the stated period, the contract terminates without any privileges even if the policyholder still lives. This cheap form of insurance is often sought by those exercising self-selection, but the mortality is kept within normal limits in well-regulated companies by careful medical selection.

The premiums for *ordinary life policies* are paid during the entire life of the policyholder. A higher mortality is experienced at times among holders of this form of policy than in the case of term insurance. This is accounted for by the fact that a certain proportion of applicants asking for term insurance were not sufficiently good risksf or that class and were granted ordinary life policies as a best offer.

The *limited payment policy* is a favorite form. The payment of all the premiums is completed within a stated number of years. A person is enabled to pay the premiums for a policy of this kind during his highest earning capacity and be free from further annoyance in his or her later years. The mortality in this class is usually quite satisfactory.

Endowment insurance affords a means for making provision for the future as well as looking after the welfare of dependents. To meet both these ends, the endowment policy is made payable to insured, the contract terminating, if he is living, at the end of a specified number of years, or to his beneficiary in the event of his prior death. This form of policy is usually applied for by those who have ample means to pay the larger premiums and who are confident that they will live throughout the stated period and receive the amount named in the contract. Self-selection, then, is a factor which may be practically disregarded in this class. The mortality, however, is not always consistently low, compared with less costly policies, a fact which may be attributed to the custom of offering endowment policies as a mild sort of substandard insurance when there are conditions or circumstances pointing to an increasing hazard and making it inadvisable to allow the risk to remain on the books of the company after a certain number of years.

The Insurable Interest.—A contract for insurance should be supported by a legal insurance interest which means that the beneficiary should have a lawful interest in the continuation of the life of the insured and not merely a passing or speculative interest in the event of the death of the insured. The beneficiary should be dependent on the insured for support, or the insured should be indebted to the beneficiary for an amount sufficient to justify the amount insured for, or the beneficiary should have some substantial interest in the life of the insured.

A complete and satisfactory explanation must be insisted upon in the case of applications from married

women, for joint insurance on husband and wife, from dependent minors, and for insurance on parents in favor of self-supporting children.

Corporation insurance is legitimate and profitable if the medical examination, inspection, and commercial reports are entirely favorable. This insurance is taken out on the life of some individual connected with the corporation, when his ability, skill, or influence is so valuable an asset that the welfare of the concern largely depends upon it.

Medical Selection.—Failure to accomplish a selection favorable enough to the company would create an impairment of the financial condition and necessitate a higher cost of insurance. On the other hand, while a low mortality is one mark of successful management, it has legitimate limits and unnecessary strictness will cause dissatisfaction. No company should expect to confine its business to gilt-edged risks and refuse the advantages of protection to good average lives.

The effects of the medical examination appear during about the first five years, but the selection at the home office must take into consideration other matters as well as the physical examination, such as personal history, family history, habits, weight, etc. The entire duration of the effects of medical selection may be estimated as about twenty years.

It is a simple matter to accept good and reject bad risks, but wide experience and good judgment are requisite for the proper disposition of lives at or near the borderline. A certain proportion of rejected and rated-up risks live up to an even beyond their expectancy. This fact, however, does not necessarily indicate errors in judgment, as risks are treated in classes, not as individuals. Walter S. Nichols secured sufficient data to compare 13,042 lives declined by his company with the general death rate of the same company. During the five years following the rejection there were 1,440 deaths among the declined risks as compared with 443 deaths according to the average general death rate of the company.

Self-selection.—Self-selection is that exercised by the applicant in his own interest and adverse to that of the company. It is always at work and will be to the end of time. Some conception of this subject may be formed by comparing the mortality among annuitants and insured lives. The purchaser of an annuity believes that he is in good health and will continue so for many years. The applicant for insurance, however, provides against the uncertainties of life. The comparison reveals a substantially lower death among annuitants than insured lives, especially during the first five years, a fact which indicates that the effects of self-selection among annuitants, exercised in their own favor, is as strong, if not stronger, than that of medical selection of applicants for life insurance.

Self-selection is especially noticeable in the following groups:

1. A fairly high death rate is observed among entrants of from fifteen to twenty-five years of age, especially among dependent minors. The self-selection, therefore, at these ages may be exercised for the applicants by other persons who are the beneficiaries or payers of the premiums, or both. The premiums are usually paid by one of the parents upon whom the insured must depend for some time to come for support, protection, and care during illness. Furtheremore, these young people are unseasoned, tender, susceptible to disease, and subject to a high mortality.

2. The death rate in the advanced ages, entrants at ages sixty to seventy, is high. This is explained to a large extent by the effects of previous strenuous business and social life. These applicants may have a legitimate reason for insuring their lives and paying the high premiums which must be exacted. On the other hand, they may have some misgivings as to their hold on life and have become anxious to make some provision for their families at the expense of other policyholders. Moreover, their long experience has made them more sophisticated, shrewd, and reticent, and they cannot be depended upon to be frank and give out information freely, if at all, in regard to their feelings and ailments.

2. Other opportunities for self-selection present themselves in the cases of men and women between fifty-five and seventy years of age who lend themselves to the designs of younger self-supporting relatives, or relatives-in-law, for the purpose of speculation, the applicant giving signs of advancing age or of some disease in the incipient stage.

4. There is an unquestionable tendency among men who feel shaky about their hold on life to over insure and the investigation, therefore, of applications for large amounts should be rigid, especially when the applicant has not previously carried a reasonable amount of insurance. Suspicion should be aroused when the issuance of a policy for a large sum is soon followed by application for another.

5. Experience, generally, teaches that the selection in the cheap forms of policies is naturally adverse to the interests of the companies, and that, consequently, the mortality varies inversely with the premium. This self-selection is a result of the natural tendency of human nature to make the best possible bargain, and some men, yielding to this impulse, present their case in the most favorable light or even practise deliberate fraud by concealing or misrepresenting important facts affecting them as risks. The experience of different companies varies however, in regard to this point. Some have adopted such a stringent selection in connection with the low-priced policies, notably term insurance, that it is not uncommon to find the death rate as low as among the holders of the higher grade policies.

6. There is a legitimate field for insurance among women, as it includes many who are independent in financial matters. On the other hand, there is a powerful force of adverse selection among these risks which expresses itself in a high mortality in certain classes. Medical examiners are apt to experience feelings of sentiment or timidity in examining women for insurance, and fail to ply all the pointed and direct questions appearing in the application blanks or to insist on complete examinations. There is, further, the natural tendency of women to avoid a discussion or belittle the diseases peculiar to their sex, and the skill with which they can hide the state of their health must be counted upon. Still further, the lack of business training with the failure to comprehend the spirit of the terms of a contract, at times may lead to statements which are not straightforward, complete, or unbiased.

7. Self-selection is frequently practised for women by some other interested person, such as the husband or some self-supporting child, either of whom appears as a beneficiary and payer of the premium. The mortality among spinsters and independent women is notably lower than that found among married women with the husband as beneficiary, especially when he pays the premiums and there are no children.

8. The policy should never be delivered to the applicant until he has paid the first premium. A period varying from thirty to sixty days is allowed the agent for placing the policy. An applicant who has grown indifferent after the examination may defer payment of the premium until this period has nearly expired, or he may decide not to take it. If, however, he becomes ill or injured during this period, he may be anxious to pay for and secure the policy. This procedure must be guarded against by an appropriate clause in the application blank.

9. Under some forms of policies, the holders are entitled to certain options either before or when the

contract matures. The holder may have the privilege of taking cash or continue the policy with the addition of the accumulated reserve, and would be more likely to follow the former course if in good health, but would probably favor the latter if in poor health. In this and similar conditions, self-selection must be guarded against by having the policyholder give notice of his choice about two years before the policy matures or furnish a satisfactory certificate of health at the time.

In order to guard against self-selection, it is the duty of the examiner and the home office officials to scrutinize the character, habits, surroundings, and financial condition of the applicant. The object of taking out the insurance, the means for paying the premium, the insurable interest, and the character of the beneficiaries should be inspected carefully.

The Medical Examination.—The successful examiner employs tact and judgment in his relations with the agent and applicant. Applicants may be lukewarm about undergoing the examination, reticent in their answers, or may display a disobliging spirit. The strong, able examiner controls his feelings and overcomes such obstacles by diplomacy but with veiled firmness. A brusque demeanor may cost the agent the loss of his applicant after days or weeks of hard labor. The time and place of appointment as arranged by the agent should be observed, unless the place is so noisy or public that an examination cannot be properly carried out. Promptness is important as delay often affords the applicant an opportunity to withdraw from the transaction. Every question without exception should be asked and a complete and definite answer should be obtained from the applicant and carefully recorded in the blank. If one or more of the answers in the report are incomplete or omitted, correspondence with consequent delay will ensue. Vague and elastic terms like "fair," "average," "moderate," "childbirth," "change of life," etc., should be avoided.

An examiner may be reluctant or unwilling to incorporate certain information in his report for the reason that it might hurt his own interests or those of a friend or patient if the facts were known in the community. It is his manifest duty, however, to give the company the benefit of his knowledge of everything of an adverse nature affecting the risk, and he can do this without publicity by means of a confidential letter mailed immediately to the medical department of the home office. The examination is of little value unless it is made under favorable conditions. Privacy is imperative so that there will be no incentive on the part of the applicant to withhold information on account of the presence of other persons. Noise and bustle interfere with the concentration of the faculties as well as the hearing of the examiner. The chest should be bared. Unless there are indications that the shirts should be completely removed, however, the following procedure may re resorted to without the danger of remonstrance from the applicant: Having removed the coat and vest, the suspenders are dropped; both shirts are then rolled up to the level of the clavicle and held there by the applicant, leaving the examiner free to proceed with the examination of the chest and abdomen. When examining the back, the shirts are rolled up similarly, the applicant holding them by a hand reaching back over each shoulder.

The recommendation of the risk should always be couched in the definite terms "yes" or "no" unless the company does substandard business, in which case a modified answer may be required. The personal and family history, having been correctly and fully recorded, may be left for consideration at the home office, but the examiner is expected to recommend acceptance or rejection on the strength of his physical examination unless he possesses certain knowledge in his possession that the habits of the applicant are unquestionably bad. In the majority of cases, however, the habits should be fully recorded and referred to the home office.

Medical examiners are apt to experience a feeling of timidity when the applicant is a woman and to apprehend the occurrence of her displeasure if all the direct and pointed questions are asked or if a complete examination is insisted upon. A woman should be treated as if she comes as a private patient, under which circumstances a physician seldom hesitates to put her through a rigid catechism and to request her to submit to a searching physical examination. The proper course to pursue is to go about the work in an easy, polite, and matter-of-fact way, courteously but with veiled firmness, insisting on the fulfillment of all the requirements. The rule forbidding the presence of a third person (even the husband) while the questions of the blank are being asked, should be adhered to rigidly, for under such conditions only may full answers, without restraint or influence, be obtained. During the physical examination, however, it is proper to have a friend or relative present. The woman should be previously instructed to arrange her clothing in a way that will insure ease, facility, and thoroughness in the examination. A loose gown of light material will not interfere with the examination or the taking of the measurements. Corsets should invariably be removed. The urine should be passed at the time of the examination, but if this is impossible, the examiner must obtain it later himself; in no case should he accept it when brought to him by the applicant or a messenger. The examiner may easily assure himself that the applicant passed the urine by arranging to have it voided in his own office or at her own residence while he adjourns to the next room. The urine should be warm when presented in the container previously given her for that purpose.

Environment.—The hygienic surroundings should be inspected, but should not be taken too seriously, as human beings do exist and thrive under unfavorable circumstances provided the conditions are not altogether bad. A fairly large number of applications for insurance come from members of the foreign elements who, while thrifty and saving, live in more or less crowded quarters, filth and squalor. These conditions, especially when the applicant works in overcrowded, badly ventilated, damp and poorly lighted sweat or junk shops, may be so unfavorable as to justify rejection.

Occupation.—The view in regard to occupation differs among various companies. Generally speaking, the occupation hazard may be classified into three groups: 1. Increased liability to accident, such as iron and tin workers, coal miners, railway laborers, engineers, firemen, workers in electricity, fishermen, seamen, saw-mill operators, etc. 2. Diseases which may be occasioned, such as that found among stone cutters, copper and lead miners and workers, grinders, file makers, potters, glass makers, plumbers, painters, etc. 3. Occupations requiring the handling of alcohol.

The conditions affecting workers are continually undergoing improvement and mechanical devices are being adopted for reducing risks.

Personal History.—It is the duty of the examiner to make a searching inquiry when there is a history of a previous illness or accident, or a suspicion of bad habits in the past or present. The results of the investigation should be recorded invariably, as the home office authorities cannot deal intelligently with a case without a knowledge of every detail. In reporting a disease, the report should always include the date, duration, severity, cause, date of last symptoms, and after-effects. Misrepresentation on the part of the applicant in giving this personal history will justify a company in cancelling the

policy within a limited period of time, and if the omission or falsification has any bearing on the cause of death during this period, the company will have the right to contest the claim.

It will be stated frequently in the following directions that certain points may be ignored by the approving officers at the home offices. The examiners should not conclude from this that the said points may be omitted from their reports.

Family History.—Family history is an important feature in the selection of risks and is often the crucial point on which acceptance, rejection, or the offer of a special form of policy is decided. Tuberculosis and other inheritable diseases in themselves do not play so prominent a rôle as formerly, as medical science in regard to these maladies is more commonly studied and observed by the public. Indications of a short or long longevity, however, is an important factor in border-line cases.

General Appearance.—The condition known as "healthy appearance" cannot be defined clearly, for while it is evident to all that a strong vitality and robust constitution are usually indicated by the complexion and tone of the tissues, there are several grades of appearance between this aspect and the earmarks pointing to present or future disease. An applicant may be noticeably pale on account of an indoor occupation or an inherited complexion, or to anemia or some other disease. He may have a full, flushed face or even dilated capillaries due to exposure to the weather without being plethoric. On the other hand, the ruddy complexion may be the result of high living and the excessive use of alcohol. Sallowness may be a natural characteristic, but should lead to an inquiry into a possible history of gastro-intestinal or gall-bladder troubles. Premature senility is usually due to business and social stress with attendant degenerative change. While a younger age than the true one may be declared in order to obtain a policy with a lower premium, the line should not be drawn too closely when there is only a slight discrepancy, as appearance in this respect is often deceiving.

Height and Weight.—Overweight seems to indicate a certain hypernutrition and robustness up to about age thirty that is favorable to subsequent life. After age thirty, the lives of men and women are shortened by a condition of overweight to a marked degree. Overweights are less able to withstand shock, operations, injuries, or disease and are more apt to develop Bright's, heart disease, arteriosclerosis, apoplexy, diabetes, and cirrhosis of the liver. Overweights with excessive abdominal measurements give a mortality of about ten to fifteen per cent. higher than those without excessive abdominal measurements.

Underweights are better risks, as a class, than overweights. They have greater endurance and better chances of surviving injuries, operations, and diseases. The combination of underweight and tuberculosis is, however, undeniably serious. Dyspepsia and underweight is another unfavorable combination.

In selecting risks, the home office will have to consider the individual merits of each case of light or heavy weight, these conditions being influenced by such factors as a personal history of gout or rheumatism, unfavorable habits, occupation, etc.

Accuracy of the measurements is especially important in overweights, and can be secured only when taken on the bare skin. The chest should be measured horizontally at the nipple line. When the applicant is a woman, the tape may be carried around the body just high enough to avoid the thick part of the breasts. Error in the measurement of the abdomen is frequent but is of small consequence when the applicant is within the limits of normal weight. In the case of overweights, however, there should be no mistake. The abdominal measurement should always include the umbilicus, but is misleading when the tape is carried around the crests of the ilia or the buttocks. Hence, the rule for measuring in a horizontal line must be departed from when dealing with a pendulous abdomen, the tape line being carried obliquely from a point on the back just high enough to escape the crests and low enough in front to reach the navel. In other words, the fat applicant with a pendulous abdomen must pay a penalty by having the measurement taken in an oblique line. When the abdominal measurement is excessive, the examiner should state whether the condition is due to fat, tumor or abdominal fluid.

The weight should be taken with the ordinary clothing on, including the coat and vest, as the tables are computed with this extra weight in mind, just as the height includes the measurement with the shoes.

Habits.—The tolerance of alcohol varies with the individual. The total abstainers as a class, however, give a more favorable mortality than is found in moderate drinkers, while the death rate among the immoderate drinkers is positively bad. Furthermore, the total abstainer is less liable to become intemperate in the future as he does not expose himself to the temptations of the bar-room, club, or private closet at his home. In general, those who have had to resort to a cure have undermined their constitutions to such an extent that, even though they have abstained for a long period since the cure, they are insurable only as substandard risks or for an endowment policy which will terminate by the time they become fifty-five or sixty years of age.

Applicants who use or have used alcohol to excess may resent any inquiry into the matter or prevaricate in regard to the amount consumed. Tact, diplomacy, and persistence are required at times, therefore, to draw out full information.

The drug habit is more difficult to detect than that of the immoderate use of alcohol. These unfortunates lie without compunction in regard to their weakness, and the appearance cannot be depended upon as evidence of the habit except in advanced cases. The shoulders and arms of all applicants should be inspected for the presence of scars arising from the use of the hypodermic needle. Applicants who are suspected of addiction to the habit of using drugs in the past or at present, should be rejected.

Diseases of the Nervous System.—The state of the nervous system receives too little attention in the majority of medical examinations; hence, the early signs of general paralysis of the insane, tabes or alcoholism are often overlooked. The facial aspect may give indication of some nervous trouble. If Bell's paralysis is present, the examiner should ascertain if the palsy is of peripheral or central origin. The eyes should be examined for inequalities and dilatation or contraction. Slight inequalities may be congenital. Changes in the pupil reflexes and the Argyll-Robertson pupil are important signals, but it must be remembered that the degree of light has a great deal to do with apparent activity or sluggishness of the pupils. Ptosis, associated with external strabismus and dilatation of the pupil, is dependent upon paralysis of the third nerve, a condition usually due to syphilis. Moderate bilateral ptosis without other manifestations may occur in hysteria and neurasthenia. A fine tremor of the protruded tongue is found in the early stages of paresis and in alcoholism. The applicant should be asked always to walk so that the gait may be observed. Other signs to be looked for are tremor of the fingers, abnormality in the patellar reflexes, Babinski's reflex, and Romberg's symptom.

Dizziness and vertigo, should be reported by the examiner, even though they may be ignored at the home office when due to gastric disturbances, biliousness, or constipation, if not too recent and the report shows

that there has been no suspicion of convulsions or epilepsy. If the applicant was over forty years of age at the time of dizziness or vertigo, however, cardiac weakness, vascular changes, and nephritis must be eliminated. Unconsciousness and fainting may have been due to injury, shock, emotion or some illness, or it may have been due to cardiac weakness, vascular changes in the brain or epilepsy. A history of epilepsy, even if remote, should cause rejection. Furthermore, a history of convulsions should lead to the suspicion of epilepsy. If the applicant has had paralysis, apoplexy, or insanity, rejection is in order. Recent neurasthenia, even if due to "brain-fag" or worry, should prompt postponement. When there is a history of headaches, due to gastrointestinal disorders, eyestrain, migraine or overwork, it may be disregarded if the headaches are not too severe or frequent. Occupation cramps, such as "writer's cramp," may be ignored by the home office authorities. Applicants who have suffered from sunstroke should be postponed until they have gone through the succeeding summer without any after-effects.

Diseases of the Circulatory System.—The personal history in regard to diseases of the circulatory system is usually meager, as in the majority of applicants for standard insurance, they are discovered for the first time at the examination. Nevertheless, it is important to ascertain if there is a history of palpitation, irregularity, or intermittency, dyspnea, or pains in the region of the heart. The mortality is high among those having irregular or intermittent pulse, and should cause postponement until the heart action becomes quite normal. If these conditions are associated with overweight, a history of rheumatism or gout, a daily use of alcohol verging on excess, or the applicant is over middle age, the risk should be rejected at the home office.

The examination of the heart is of little value unless the chest is fully exposed. Every murmur does not point to valvular disease. True functional murmurs are apt to be associated with anemia or some special attack upon the resources of the body. Rapid heart action in some individuals gives rise to a temporary murmur due to imperfect closure of the valves. Dynamic murmurs may be produced at the base. Cardio respiratory murmurs are frequently heard and may be difficult to differentiate from organic murmurs. The position of the applicant will often assist the examiner. True cardiac murmurs are usually affected by the position of the body through a change in the blood pressure. Some organic systolic murmurs which are almost inaudible during the erect posture, may be heard easily when the applicant lies down. Accentuation and reduplication of both sounds are not uncommon, but do not persist in health.

The pulse should not exceed ninety. It should be counted for a full minute so that the frequency, quality, and rhythm may be determined accurately. In the event of any abnormality at the first examination, the pulse should be taken again to eliminate any element of nervousness, recent vigorous exercise, a recent meal, loss of night's sleep, or the drinking of strong tea or coffee.

The systolic blood pressure is an important indication of disease. The diastolic pressure will undoubtedly prove a valuable addition to medical science when it has been studied and is more completely understood. The limit of systolic pressure may be placed at about 145 to 155 millimeters for insurance purposes. All portable forms of sphygmomanometers are more or less faulty, hence the best obtainable should be purchased. These instruments, whether mercurial or aneroid, should be kept in perfect order and frequently checked up with standard instruments. Unless this precaution is observed, the findings are unreliable. If the pressure is above the normal subsequent readings should be taken on different days, as high blood pressure is significant only when permanent. If the diastolic pressure is required, the auscultation method should be employed.

The arterial walls should be examined on the two sides of the body, as it is not uncommon to find a perceptible thickening on one side only.

Disease of the Respiratory System.—Applicants who have had pulmonary complaints are apt to acknowledge a history of the trouble with reservation, if at all, especially if it was serious. Any admission or suspicion of lung or throat trouble or pleurisy should prompt the examiner to make an unusually searching inquiry and examination. If the applicant acknowledges chronic cough or hoarseness, the examiner should keep the possibility of tuberculosis in mind. On the other hand, an ordinary catarrhal condition of the nasopharynx may be trivial. Coughing or spitting of blood is usually described as bleeding from the nose or the gums about the teeth. Unless a certificate can be obtained from a physician who saw the bleeding point at the time, it is a good practice to postpone the applicant at least ten years. Pneumonia should lead to postponement of from six months to a year from the date of the attack. Pleurisy, dry or with effusion, is so often of a tuberculous nature or followed by tuberculosis later on, that an applicant who has had an attack should not be accepted until about five years have elapsed unless all features are exceptionally favorable. Asthmatics are not acceptable risks unless at least a year has gone by since the last attack; if the attacks were frequent or numerous, however, the applicant should be declined.

The examination of the lungs should be made under the most favorable conditions, especially when there is a suspicious personal history or a tainted family record, the chest being bared in front and behind. The examiner is liable to meet cases of pulmonary tuberculosis in the earliest stages without a history of symptoms pointing to this condition. At the same time, it is well to remember that every deviation in the chest does not necessarily indicate the presence of disease. The physiological difference in the percussion note or respiratory sounds between the two sides of the chest may be exaggerated in healthy individuals.

Diseases of the Digestive System.—The diagnosis in this class of diseases is often difficult, as grave disorders may be masked, the symptoms pointing to some comparatively unimportant ailment. Furthermore, while the trouble has apparently passed away, it may lie dormant and be liable to recur. A history of any gastrointestinal disorder, such as dyspepsia, indigestion, biliousness, pain, colic, or diarrhea, should prompt the examiner to inquire closely into the possibility of appendicitis, gallstones or some other serious trouble. In addition to this, the home office authorities will often ask for a certificate from the physician who saw the applicant during the attack in order to ascertain the real nature of the ailment as far as possible. An applicant with a history of hematemesis, ulcer of the stomach, or a gastroenterostomy performed for ulcer of the stomach, should not be considered for atle ast ten years. A shorter period will answer if the operation was performed for ulcer of the duodenum.

Appendicitis, one attack without operation may be overlooked if there has been no recurrence for at least a year. When there has been an operation with primary union and no complications, it is safe to insure the applicant in three or four months, but a certificate from the operating surgeon should be furnished. If there were extensive adhesions, pus, drainage, or serious complications, the lapse of a year should be required.

Applicants with a history of gallstones should not be accepted until about five years have gone by since the last manifestations, but the risk may be accepted in two years if the stones have been taken out and the gall-bladder drained or removed.

The physical examination of the abdominal organs does not always yield satisfactory results. Nevertheless, the viscera should be mapped out and examined by deep pressure for the detection of tenderness or tumor.

The acknowledgement of hemorrhoids calls for further inquiry. Many individuals with supposed hemorrhoids have been found to have fistula, tuberculosis, or malignant trouble. An applicant over forty years of age should be requested to furnish a statement from the attending physician, giving the exact nature of the trouble. It is not wise for the examiner to make an instrumental examination.

Diseases of the Genitourinary System.—Degenerative changes in the kidneys are responsible for a large mortality. An applicant with a history of acute Brights way be considered if several years have elapsed since recovery and a careful chemical and microscopical examination of the urine at the home office in addition to the regular urinalysis by the examiner, gives negative results.

Renal colic may be ignored by the home office if there has been one attack only, provided the urine is negative chemically and microscopically, and a period of six months has elapsed. If the applicant is over forty years of age, a year should elapse. No applicant with a history of renal colic and calculus should be accepted if his weight is more than twenty per cent. above the standard. Hematuria should lead to rejection until about five years have elapsed, unless it was due to the passage of a renal calculus. Movable kidney is sufficient cause for rejection unless the kidney has been successfully fixed and time enough has gone by to indicate that it will remain in place. Nephrotomy need not bar the applicant from insurance if there was no suspicion of tuberculosis or malignancy and two years have elapsed. Removal of a kidney warrants rejection. The liability of persons over fifty to enlargement of the prostate should be kept in mind when there is any irregularity in micturition. When there is a stricture or a suspicion thereof, the applicant should furnish a statement from his physician giving the size of sound that can be introduced. For insurance purposes the size should be at least No. 26 French.

Albuminuria and glycosuria should always be regarded as abnormalities. Fortunately, the abnormality is of little consequence in a large proportion of the cases. The gravity of the underlying condition is determined by whether the albuminuria or glycosuria is transient or permanent. If the urine is found to contain either of the ingredients, or there is a history of their appearance, three normal consecutive samples and a statement as to whether or not the applicant has been under treatment or restricted diet, will usually be required.

Examination of the Urine.—If the urine is outside the limits of specific gravity prescribed by the company, usually 1,010 and 1,030, another sample should be examined.

If the heat test gives no reaction, albumin is not present. If the reaction is positive, differentiation may be accomplished by the use of Heller's test, letting the specimen stand at least fifteen minutes but observing it every few minutes. If there is no layer of coagulated albumin at the line of contact, the result is negative. A diffused cloudiness above a clear layer of urine indicates the presence of nucleoalbumin.

If one of the reduction tests gives no reaction, sugar is not present. If the reaction is positive or doubtful, it should be corroborated by the fermentation test.

Hyaline and granular casts are significant when they persist. They may appear, however, for a limited time, in unimportant conditions; consequently the examination of several specimens should be made. If the casts persist the applicant should be postponed or declined according to the number and kind of casts and the condition of the applicant in other respects.

Malaria.—The mortality among applicants with a history of recent severe or frequent attacks of malaria is high, especially in the southern part of the United States. Intermittent malaria should not be ignored until three or more months have gone by according to the particulars of the case. Remittent malaria calls for a postponement of about twelve months. When there is a history of hematuria, rejection until five years have elapsed is a wise precaution, especially if the applicant still lives in the locality where the attack was contracted.

Rheumatism.—A policy may be granted on the life plan if there has been but one attack at least one year previous. A substandard or endowment policy may be offered when two or three attacks have occurred, provided cardiac involvement did not complicate the case. If more than three attacks have occurred, rejection is advisable unless a long period of time has gone by since the last attack. An occasional twinge in a joint without previous swelling, inflammation or actually severe pain is unimportant. Muscular rheumatism is of no consequence unless chronic, in which case an endowment or rated-up policy is in order.

Gout.—Most cases of gout should be rejected. If there were only one or two attacks, undoubtedly mild, an endowment or rated-up policy may be offered after five years from last manifestations, provided the heart blood-vessels, blood pressure, and urine are unquestionably normal.

Syphilis.—The mortality among insured lives with a history of syphilis is excessive. If accepted at all, at least four years should have elapsed since the date of the last manifestations and treatment. The blood pressure should be carefully taken as the vascular system may have undergone changes. Tertiary syphilis justifies rejection. Serology and chemotherapy may make some modifications in these suggestions. It must be remembered, however, that the Wassermann test in its present standing is practically useless in cases which have gone one or more years without manifestations. The provocative Wassermann test gives somewhat better results, but is still far from satisfactory. The best means available for establishing the fact whether the spirochetes of latent or dormant syphilis are deposited in the spinal fluid and perivascular spaces beyond the reach of the blood tests, is impracticable in life insurance examinations, as it necessitates lumbar puncture in order that the spinal fluid may be subjected to a complete test. When applicants with a history of syphilis are accepted, the policy offered must be on an endowment plan which will terminate at about the age of fifty-five or a rated-up policy.

Abscess, Ulcer, Tumor.—A history of one of these conditions should be accompanied by a full account of any surgical interference and pathological findings. If there has been no operation, the examiner should endeavor to ascertain the nature and cause, and if there was any suspicion of syphilis, tuberculosis, or malignancy.

Diseases of the Skin.—Suspicion of syphilis, tuberculosis or malignancy should be cleared up. When a large area of the applicant's body is covered with eczema, psoriasis, or other benign eruption, there is apt to be some constitutional dyscrasia which, in the opinion of some, calls for the offer of an endowment or a rated-up policy.

Diseases of the Nose.—The ordinary and simple catarrhal trouble are of no consequence. Polypus calls for postponement for six to twelve months after the date of removal, according to the number of recurrences. Chronic sinusitis should have ceased for at least a year before acceptance.

Diseases of the Ear.—When there has been a discharge during the past one or two years, the applicant should furnish a statement from a competent aurist in regard to the present condition of the ear, and state whether or not there are any granulations,

polypi, or carious bone. Applicants may be accepted if the statement is favorable unless the discharge is or has been recently bloody or offensive.

Surgical Operations.—The applicant should furnish a statement from the operating surgeon in most instances, giving the dates, diagnosis of the condition for which operation was done, the nature of the operation, the structures involved, the end result, and stating whether or not there was any suspicion of tuberculosis or malignancy.

Deformities or Loss of Limb.—A risk is not a good one if there has been amputation at the hip-joint, and, according to some, at the shoulder-joint. In all amputations, the condition of the stump should be known. If the applicant uses crutches, he should be rejected. In hip-joint disease, it is important to know if the original trouble was tuberculous or not. The hip should be inspected for scars which would indicate that the process was tubercular. In spinal curvature it is essential to know whether the curvature is lateral or anteroposterior. The former is no bar to insurance unless excessive. The latter should cause rejection.

Hernia.—When hernia is present it should be ascertained if trouble was ever experienced in reducing it and if the parts are well maintained in their proper position by a truss.

Substandard Insurance.—A man who is physically impaired is in greater need of insurance than a sound one. This want can be supplied up to a certain point, beyond which the cost becomes prohibitive. The sources of increased hazard are unfavorable family history, poor general appearance, unhygienic surroundings, adverse habits, hazardous occupations, previous disease with a liability to recur or to lead to other disorders, existing disease, or lack of vitality. These hazards may be covered by the following methods: 1. Simply increasing the premium, practised by some companies in the cases of women, complete deafness, and some occupations. 2. Advancing the age. This method is the one commonly followed in this country. 3. Placing a lien upon the policy which allows only a stated part of the face value to be paid if death occurs within a stated period during the early policy years, the amount to be paid gradually approaching the face value as the policy becomes older. This is substandard insurance in the true sense of the word, especially when the hazard is an early one. All companies transacting business in the State of New York, however, must conform to the statute of the Armstrong law, which prescribes certain standard forms of policies. These standard forms do not provide for the payment of less than the face value of the policy at any time in the case of death. 4. The issuance of endowment policies which mature at certain ages to cover slight impairments, especially when the risk is an increasing one. This method throws a burden upon the endowment class in the form of risks not good enough for lower premium policies. The best available method, then, is that in which the age is advanced.

The companies which have been writing substandard insurance long enough and upon large enough scale to perfect their methods show no desire to impart the results of their difficult and expensive studies to competitors. It is impossible, therefore, to give definite tables and figures upon which a company could undertake immediately the insuring of substandard lives, as there are no fixed or universal ideas on this subject. Each company must depend upon its individual experience and start with empirical methods until it can reach the point where the business becomes profitable. A company, even when working on a large scale, finds it necessary to continually revise its estimates, lowering the rate on a certain class when it is found that too heavy a charge is imposed, or raising it when a certain part of the business is transacted at a loss. Furthermore, a company will find its ratings too low for some sections though appropriate for the rest of its territory. It must be the constant endeavor, then, to keep the rates at a fine point of adjustment so that the company will work with a conservative margin of safety and, at the same time, offer fair and equitable terms to the applicants.

In order to build up a satisfactory system for insuring impaired lives, the medical directors and actuaries must act in conjunction, ascertaining the mortality in the different classes from their individual experience and that of others. The computations must be made from the death rates, year by year and not by the total number of deaths after a prolonged period. When definite ideas have been formed after these considerations, the actuaries will be in a position to convert the percentages of mortality into the number of years to be added to each age in the different forms of policies, the premium charges being those due for the advanced ages. Henry H. Schroeder.

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